R E P O R T

UPON THE

C O M P R E H E N S I V E   P L A N

FOR THE

C O L L E C T I O N , P U R I F I C A T I O N A N D D I S P O S A L

OF THE

SEWAGE

OF THE

CITY OF PHILADELPHIA

DEPARTMENT OF PUBLIC WORKS

BUREAU OF SURVEYS

1912

Director

South West Works
North East Works
Delaware River Intercepting Sewer via Oregon Ave.
East Schuylkill Intercepting Sewers
Shaft
Schuylkill River
Inverted Syphon
West Schuylkill Intercepting Sewer
Cobbs Creek Intercepting Sewer
Screen & Grit Chamber
Pumping Station
Shaft.
Screen & Grit Chamber
Force Mains
Church Creek
Distributing Main.
Operating Tower
Influent Weir Houses.
Constant Head Houses
Regulating Houses
Bypass
Sedimentation Tanks
Sludge Drying Beds
Filter Influent Conduits.
Percolating Filters.
Effluent Conduits
Sludge Pumping Stations and Mains.
Settling Basins.
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Back Channel
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Submerged Outfalls
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Southwest Works
Section G
Section H
Section I
Section J
Section K
Northeast Works
Section A
Section B
Section C
Section D
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Sedimentation Tanks
Constant Head Houses
Sludge Drying Beds
Distributing
Operating Tower
Intercepting Sewer from Frankford Creek
Mains
Sewer
Filter Influent Conduits
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" " " " 1910

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Scope of Report.

This report embraces a discussion of the local conditions, the studies of both preliminary and future aspects of the problem, with a summary comprising a comprehensive plan for the sanitary collection and disposal of the sewage of the entire city.

In addition to formulating a plan and in order to improve the City's sanitary condition at an early date, recommendations are made to construct the works step by step in logical sequence, beginning with treatment to a limited degree, with a view to utilizing the natural advantages of the City for disposal by dilution as far and as long as practicable, recognizing other municipal needs of equal importance, and the limitations of the City's borrowing capacity, subsequently adding to the first constructions as proper sanitation requires.

Authorization.

On July 20th, 1907, His Honor, the Mayor of the City of Philadelphia, John E. Reyburn, approved an ordinance of Councils entitled "An Ordinance to authorize the Department of Public Works to make investigations and report upon a comprehensive plan for the collection, purification and disposal of the sewage of the City, together with such alterations and extensions of the existing sewerage systems as may be necessary, and to make an appropriation therefor." The ordinance provides, in part, as follows:

WHEREAS, By an Act of Assembly of the State of Pennsylvania, entitled "An Act to preserve the purity of the waters of the State for the protection of the public health," approved April 22, 1905, it is provided, among other things, that "No person, corporation or municipality shall place, or permit to be placed or discharge, or permit to flow into any of the waters of the State, any sewage, except as hereinafter provided, etc." Also, that "Whenever it is their unanimous opinion (Governor, Attorney General and Commissioner of Health), that the general interests of the public health would be subserved thereby, the Commissioner of Health may issue a permit for the discharge of sewage for any such sewer system into any of the waters of the State, and may stipulate in the permit the conditions on which such discharge may be permitted," revocable at any time; and

WHEREAS. the Governor of the State, the Attorney General and the Commissioner of Health have by various permits granted the right to the City of Philadelphia to extend various sewer systems, and to discharge the sewage into the waters of the State subject, among others, to the following conditions: "That the City shall, on or before the year one thousand nine hundred and twelve, prepare and submet to the State Department of Health, for approval, a comprehensive sewerage plan for the collection and disposal of the Sewage of the various drainage districts of the City," and another conditions as follows: "Extensions shall be immediately approved, provided some progress shall be made each year in the study of a comprehensive system of sewerage for the various drainage districts, and provided that said sewer extensions shall not, as far as practicable, be at cross purposes with said comprehensive system;" now, therefore,

Section 1. The Select and Common Councils of the City of Philadelphia do ordain, That the Department of Public Works be authorized and directed to make investigations and report upon a comprehensive plan for the colection, purification and disposal of the sewage of the City, together with such alterations and extensions of the existing sewerage systems as may be necessary; also to carry on experiments and report upon the feasibility of the treatment of sewage, together with estimates of the probable cost of altering the present sewage systems as far as may be required, of constructing necessary outfall sewers, of constructing disposal works, and the maintenance of the same.

Section 2. The Director of the Department of Public Works is hereby authorized to employ in consultation such engineers and bacteriologists as may be requisite to reach a satisfactory solution of the problem; and also to employ such engineers and assistants as may be required for making surveys, investigations, experiments and recommendations; all expenses for salaries, inspection, tests, transportation, and incidental expenses, not otherwise provided for, shall be paid out of the appropriation for the work herein authorized.

Sub-Division of the Investigation.

The investigation ordered by Councils divides itself into the following subjects:

A comprehensive plan for the collection, purification and disposal of the sewage of the City.

Alterations and extensions of the existing sewer system.

Experiments and report on the treatment of sewage.

Estimates of the cost of altering the present sewer system.

Constructing intercepting sewer systems and disposal works.

Maintenance of Disposal works.

Organization.

The investigations have been carried on and plans prepared by the Bureau of Surveys, Mr. George S. Webster, Chief Engineer, Mr. George E. Datesman, Principal Assistant Engineer, Mr. W. L. Stevenson, Assistant Engineer, (Sewage Disposal), Mr. Charles Frommer, Assistant Engineer, (Sewer Design) with the aid of a corps of assistants organized into a Sewage Disposal Division.

Acknowledgement.

Dr. Rudolph Hering, Consulting Engineer, was engaged to advise in connection with the experiments at the testing station and upon the

studies for the comprehensive sewerage plan.

Acknowledgement is also made to Mr. F. C. Dunlap, Chief, Bureau of Water, and to his assistant Dr. George E. Thomas, Chemist, for assistance and valuable advice.

SUMMARY OF CONCLUSIONS.

1st. The adoption of a satisfactory plan for the disposal of the sewage of the City, so arranged that it may be carried out in pregressive parts as the increase of population and the necessities may demand.

2nd. Division of the system into two parts, each having a disposal works, one to be located in and to take the sewage from the Northeastern portions of the City, and the other to be located near Penrose Ferry bridge to take the sewage from the balance of the City.

3rd. The acquisition of land for the disposal works adequate in area to serve the future requirements.

4th. The construction of intercepting sewers to prevent the flow of sewage into the smaller streams within the City limits, and to conduct the sewage to the main interceptors which will carry it to the points of disposal.

5th. The construction of intercepting sewers to remove the pollution from the Schuylkill and to conduct the sewage to the Southwest Pumping Station and ultimately to the disposal works on the Delaware river below the mouth of the Schuylkill river. The construction of similar intercepting sewers along the Delaware river, some leading to the Northeast and some to the Southwest stations. Also, the construction of necessary chambers and devices to automatically divert the sewage from the combined conduits to the main intercepting conduits, and also the necessary tide gates at the outfalls of the combined sewers.

6th. The construction of pumping stations at each of these works and submerged outfalls into the river.

7th. The preliminary treatment of sewage through screens and grit chambers.

8th. The construction of two story sedimentation tanks and of sludge drying beds.

9th. The making of necessary repairs to and alterations in the existing sewer system to bring it to a modern state of efficiency, and to adapt it to the general plan recommended.

10th. The operation of the works for a period of time without the addition of processes for greater refinement, adding these as the necessities require, and as funds are provided.

11th. The division of the construction into sections in sequence, proportioned to the amount of money which may be appropriated from time to time.

12th. The designing of main sewer extensions so that they may conform to the accepted plan.

13th. The undertaking of such parts of the work at first which will relieve the inland streams from pollution, and improve the quality of the water at the intakes of the water filtration works.

14th. The division of the disposal works in separate complete working units, so that treatment of the sewage may be carried on, without delaying until the accomplishment of the complete plan.

15th. Withholding approval of their construction, awaiting a further advancement in the science, it nevertheless follows that the complete plan as outlined requires the construction of percolating filters.

16th. Also construction of settling basins.

looking to the prevention of pollution of the rivers, involving changes in the means of disposal of such wastes, ~~as were~~ responsible for this condition.

Modern sanitation may be said to have had its initial impulse from the researches of Dr. Edward Frankland, of England, who was a member of the "Rivers Pollution Prevention Commission" in the years succeeding 1868. Subsequently much legislation was passed regulating the entrance of trade wastes into the streams and various Boards were created and clothed with power to preserve the waters from pollution, by requiring treatment of those wastes and sewage before being discharged into the streams.

The first measures of this nature in this country were taken by the people of Massachussetts, who, realizing that the problem which had confronted the more concentrated populations of England would ultimately arise among the New England towns where sources of water supply were few and inconsiderable in size, secured the passage of legislation about 1886 authorizing the establishment of a laboratory under the State Board of Health. The work of this laboratory began in 1888, and has continuously been carried on until the present. The lines of examination followed somewhat after the procedure proposed by Dr. Edward Frankland in the English investigations. The necessities for purification of sewage in England were so urgent that large expenditures for experimental and working sewage disposal plants were made, the work of the Massachussetts State Board of Health being a valuable aid to the Engineers of England in this regard.

In the meantime Germany and France had made considerable progress in the study of the question and in the construction of sewage disposal works. The American Cities, in a great measure, have been making use of the rivers and streams as the quickest method of disposal, but the growth of population in recent years attended with the increase of water consumption and the desire to raise the standard of the water supply has brought forth a strong popular demand for the preservation and conservation of the waters, which makes the matter

of treatment of sewage of great importance.

Present Conditions.

Boards of Health have been created and in order to stamp out diseases, the sources of which are attributed largely to the drinking of impure water, and which contribute in a large measure to the high death rate in communities where the sanitary arrangements are not satisfactory, they have insisted upon an improvement in the methods of sewage disposal and have been granted large powers by the legislative bodies of the various commonwealths.

The Legislature of the State of Pennsylvania following the popular demand, on April 22nd, 1905, passed an Act creating a State Department of Health, having a Commissioner with large powers to compel municipalities, corporations and individuals to improve conditions wherever they are found to be unsanitary or injurious to the communities. Cities have been notified to prepare plans for improvement of sewer systems and methods of sewage disposal throughout the State. Among others, the City of Philadelphia is required to prepare and forward to the State Department of Health a comprehensive plan for the collection, purification and disposal of its sewage as indicated in the terms of the permit granted to the City under date of April 23th, 1907 for the extension of its sewer system, which among other things provides as follows:

"First" That the City shall on or before the year one thousand nine hundred and twelve, prepare and submit to the State Department of Health for approval, plans for the collection and disposal of the sewage of the City.

"Second" The City shall, in the interim, forward plans and lists of sewers authorized to be built by councils of the city, from time to time, giving the name, size, length of each sewer extension, referring by number to the positions of said extensions upon the plans, to the State Department of Health, which extensions shall be immediately approved provided some progress shall have been made each year on the comprehensive plan for the entire district.

"Third" No pathological material from any laboratory shall be discharged into the sewer system. The proper authorities shall cause these wastes to be incinerated on the premises.

Preliminary Arrangements.

In order to comply with the Ordinance of Councils, authorizing investigation of methods to prepare for a better system of sewage disposal, the Bureau of Surveys has utilized the old testing station of the Bureau of Filtration, after some alterations, to experiment upon methods of treatment and sewage disposal to determine which combination would be best adapted to the local conditions, the result of which investigation, after being carried on over a period of fifteen months was given in a separate report published and printed in the year 1910 by the Bureau of Surveys.

Visiting Sewage Works.

Prior to placing this experiment station in operation, in January 1908, Mr. George R. Stearns, Director, Department of Public Works and Mr. George S. Webster, Chief Engineer, Bureau of Surveys, were commissioned by His Honor, the Mayor, John E. Reyburn, to investigate the question of sewage treatment and various methods of disposal in use in England and on the continent of Europe; a report of which visit was made under date of Feb. 29th, 1908. Both before this visit and afterward the officials of the Bureau of Surveys charged with the solution of the problem, visited at various times, sewage disposal works in course of construction or in operation in a number of cities in the Eastern part of the United States, and collected valuable data bearing upon the subject.

Chapter II

TOPOGRAPHY AND PRESENT SEWER SYSTEM OF PHILADELPHIA

Topography.

The City of Philadelphia, Pennsylvania, is situated above the confluence of the Schuylkill and Delaware rivers, the most congested portion lying between the rivers, although closely built areas lie on the banks of the tributaries to both rivers. A considerable portion, about one third,

of the urban section of the city lies West of the Schuylkill river between it and Cobbs creek, which forms the Westerly boundary line.

The total area of the City is 129.583 square miles, about 60% of it comprising the area draining directly into the Delaware river, the remainder into the Schuylkill river and tributaries.

The topography of the City may best be described as rolling. The elevation of the business centre of the City around City Hall is from 38 to 40 feet above high tide and from this point Eastward, Westward and Southward there are gradual slopes toward the rivers. From City Hall Northward to Fairmount avenue, the rise is very slight. In the portion North of Fairmount avenue from an elevation of about sixty (60) feet above high tide, the ground rises gradually Northward and Northwestward to a maximum elevation of 443 feet; in the Northeasterly portion of the City there is a high plateau with average elevation of from 100 to 125 feet above high tide, from which the ground slopes gradually towards the low plain bordering the Delaware river. In the portion of Philadelphia West of the Schuylkill river, the ground is generally high and rolling, rising from the river Westward and reaching a maximum elevation of two hundred and ninety-four (294) feet above high tide, with the exception of a considerable area amounting to about 4,000 acres which would be inundated at every high tide if it were not for the protecting river banks. This condition also exists between the rivers in the Southerly section below Oregon avenue.

As the topography has an essential bearing upon the sewer system of a city, it may be stated that the main sewers of the comprehensive system are designated by the names of the valleys in which they are constructed, or by the streets upon which are their main outfalls. In the Delaware basin, there are such sub-divisions as the Gunners run, Frankford, Pennypack, Wingohocking, Cohocksink creeks, etc., in each of which cases, in place of the original open creeks, there have been built covered conduits or sewers carrying the drainage from the territory tributary thereto.

In the portion of the City West of the Schuylkill river there are

such sub-divisions as the Cobbs, Mill and Mantua creeks, Thomas run and others, the names for which are purely local.

For convenience the main drainage areas are designated by districts as follows: Delaware river, Schuylkill river, Cobbs, Pennypack and Frankford creeks.

The Existing Sewer System.

The existing sewer system is the result of a growth more or less systematic from a time preceding the year 1855, the year of the consolidation of the various boroughs and townships in Philadelphia County, from which most of the City's records are dated. The mileage of main and branch sewers prior to 1855 and after that in each decade to the present are as follows:

Table of Sewer Construction by Decades.

	Miles of Sewers	
Period	Main	Branch
Prior to 1855	18.00	19.50
1868	5.20	24.00
1870	5.12	26.39
1880	16.29	83.94
1890	27.57	174.67
1900	71.06	341.75
1910	42.401	195.805
TOTALS ---------	185.641	866.055

Note: 162.15 miles additional not included in table recently added to the total, gathered from all sources.

The building of sewers in the different boroughs and townships comprising the City of Philadelphia, within the County, was carried on prior to 1855 as the needs arose for carrying drainage from built up sections into the nearest large stream and for enclosing the channels of streams which intercepted them. Between 1855 and in 1863, the methods of construction followed precedent. From 1863 to 1876, the

Chief Engineer and Surveyor made plans, and specifications; from 1877 to 1884, in addition, he controlled the appointment of inspectors, although the work of construction was done by the Department of Highways. After the latter date, the whole responsibility was placed upon the Department of Surveys, after 1887 known as the Bureau of Surveys.

About the year 1878, great improvements were made in principles of design and methods of construction. The principal of preparing plans of the various drainage areas, which naturally divided the City into districts was established and the determination of sizes and general alignments of all main and tributary sewers, to which, the construction of all sewers, was made to conform. In Sewer design provision has been made for main stems and branches proportionate in size and capacity to the work required of them, The coefficients of run-off having been increased to meet modern conditions in sewer construction, the incorporation of improved materials into the later sewers will add greatly to their length of service.

The percentages of the total mileage of sewers constructed during the last 10, 20 and 30 years may be seen on the following table, compiled from that preceding:

Percentage of Total Mileage of Sewers, built in last 10, 20 and 30 years

	Main Sewers		Branch Sewers	
Period	Miles	Percentage of TOTAL	Miles	Percentage of TOTAL
1900 - 1910	42.4	22.9	195.81	22.5
1890 - 1910	113.46	61	517.55	59.6
1880 - 1910	141.03	76.2	712.22	82.2

it will be noted from the table that more than 20% of the main and branch sewer system has been built since 1900; that more than 60% has been built since 1890, and that more than 75% has been built since 1880, that is, more than three-fourths of the present system has been built under the modern design and construction.

The total mileage of sewers built and in operation, together with their cost as of January 1, 1911, is as follows:

Total Length of Sewers Constructed		Cost
Main Sewers ------185,641 Miles		$15,312,541.54
Branch Sewers ----866,055 "		14,392,399.93
Private Sewers ---141,095 "	(Estimated, not recorded)	2,235,000.00
Misc. Sewers ----- 21,050 "		1,772,464.11
		$33,712,505.58

(Note: as studies were made under 1910 conditions, and based upon the sewers this table has not been carried beyond that time.)

Types of Construction.

The older sewers built from 40 to 80 years ago were built of brick and lime mortar. In some cases, the bottoms were laid without mortar joints as the theory at that time was that sewers laid in this way would serve to extract the sub surface water from the soil and carry it through these channels to the rivers. It was not the practice at that time to connect water closets with sewers. Later, this method of sewer construction was abandoned. When hydraulic cement came into use it was substituted for lime and its use has added greatly to the life of the sewers.

Twenty-five years ago, the construction of vitrified clay pipe sewer was introduced; the improvements in the manufacture of this class of material has favored its continuance and it is used largely. The development of the uses of concrete has resulted of late years in the building of a considerable number of large sewers of concrete reinforced with steel. The latter is the newest type of sewer construction and is used wherever conditions are suitable.

Methods of Collection and Disposal

In the earlier days of the City, sewers were constructed from the villages to the nearest large stream and the sewage allowed to run directly into them. As the population and hence the amount of sewage introduced into these streams has increased, they have become very foul and objectionable to the adjacent residents. With the expansion of the City, these streams have largely been directed into main sewers

which carry the drainage to outfalls at the banks of the rivers.

The principle upon which the City of Philadelphia is sewered is divided into two parts, the so-called separate system, where the house drainage is carried in a separate pipe or conduit from the storm water, and the combined system, in which both the house drainage and storm water are carried in the same conduit.

The separate system is constructed upon the territory tributary to Wissahickon creek and to the Schuylkill river above Fairmount dam, the conduits carrying house and factory sewage connecting into an intercepting sewer built along the East bank of the river and emptying therin, below the dam. Fairmount dam for many years has been the forebay for the water supply of a large area within the City.

The combined system is at present used in all other parts of the City. During the past few years, intercepting sewers have been built along a number of creeks, to gather the dry weather flow in the combined sewers and carry it to points more remote from population, which sewers will be extended to disposal works in conformance with the comprehensive plan.

In the earlier days, the streets of the City were paved generally with cobble stones. Within the last twenty-five years, these cobble stones have given place to more modern materials; granite block, vitrified brick and block, asphalt and granolithic pavement. The streets as originally paved did not readily permit the storm water to be carried off, but allowed a large percentage of the rainfall to percolate through the soil. The construction of an increasing number of improved pavements, however, and the paving of large yard areas with impermeable materials have given rise to a new condition, resulting in the rapid run-off of the storm water and allowing it to reach the sewers in shorter time and in greater volume than was the case under the old conditions, causing congestion in the old sewers and requiring the building of relief sewers to carry it off without damage to property.

The increase in the number of miles of impermeable pavement has also shown the inadequacy of the number of inlets that were sufficient

under the old conditions. It is therefore necessary to continue the construction annually of a large number of inlets, in order that water may be carried more quickly into underground channels, thence to the rivers.

Chapter III

WATER SUPPLY OF PHILADELPHIA.

Sources.

The water supply of the City of Philadelphia is obtained from the Schuylkill and the Delaware rivers. The Schuylkill river is the source of supply for the Belmont, the upper and lower Roxborough and Queen Lane Filter Plants, and the Delaware river is the supply for the Torresdale Plant.

Quantity Used.

The total amount of water pumped for water consumption during the year 1911 was 116,044,866,000 or an average daily consumption of 317,930,000 gallons, equivalent to a per capita consumption per day on an average of 201.6 gallons. Sixty five per cent of the water supply is taken from the Delaware river and thirty five percent from the Schuylkill river.

Quantity of Flow of Rivers.

Schuylkill River.

The ordinary low summer flow of the Schuylkill river at Philadelphia is about 200,000,000 gallons per day and the lowest monthly flow recorded was in August 1909 at a rate of 115,000,000 gallons per day.

Delaware River.

The Delaware river is tidal as far as Trenton, so that a practically unlimited supply of water is available at Philadelphia. The flow from the watershed of the Delaware river above the Torresdale intake, which represents upland water, is estimated to be 1,313,000,000 gallonsper day

during most extreme drought and 2,600,000,000 gallons per day during normal conditions.

Physical Conditions.

Delaware River.

The intake for water supply from the Delaware river is situated at Torresdale about one half mile above Pennypack creek and four miles above Frankford creek.

The main sources of pollution of the Delaware river above this point are Burlington, N. J., Bristol, Pa., Trenton, N. J., Easton, Pa., Philipsburg, N. J., Bangor, Pa., Bethlehem, Pa., and Allentown on the Lehigh river.

Aside from these sources, the wastes from Philadelphia and Camden, N. J., provide the greatest per centage of pollution, and the river being tidal, this latter pollution effects the character of water at the intake of the Torresdale water filters.

In 1905, it was estimated that 1,800,000 persons dwelt upon the watershed of the Delaware river above Philadelphia (exclusive of the Schuylkill river watershed)

Schuylkill River.

The number of towns and amount of pollution which exist upon the watershed of the Schuylkill river have been shown in the various sanitary examinations and reports made by or for this City.

In 1905, it was estimated that 1,200,000 dwelt upon the watershed of the Schuylkill river. Care has been taken to remove sources of pollution of the water supply of Philadelphia from this river from within the borders of the City. The amount of pollution, however, discharged through existing sewer outlets into the Schuylkill river below Fairmount dam (below the point from which water supply is taken) comprises such a large proportion of the actual flow (exclusive of that consumed in water supply), that it has of recent years been a matter of serious complaint and is an ever increasing nuisance to the comfort of the people adjacent to the river below Fairmount dam.

Below the Confluence.

The effect of the pollution which reaches the Schuylkill river is felt chiefly by the residents of the City bordering upon its banks; that of the Delaware river on account of the large volume of tidal flow, has not created conditions objectionable either to sight or smell to the citizens of this City.

There are two cities which are interested together with Philadelphia in the matter of pollution of the Delaware river including that of the Schuylkill river, namely: Chester, a City of 38,533 Population, situated 19 miles below the confluence of the rivers above mentioned, and Wilmington, with 87,400 population, situated 21 miles below.

The former city takes its water supply, amounting to a pumpage of 3 millions, eight hundred thousand gallons daily from the Delaware river.

The latter city does not use the Delaware river as a source of water supply.

Both cities filter the water supplies before delivery to the consumers, to which cause doubtless may be attributed the lack of specific complaints.

Chapter IV.

DISCUSSION OF THE PROBLEM.

Intimate Relation of Water Supply and Sewage Disposal.

In examining the conditions of a water supply, the following matters must be considered: the number of cities and their population upon the tributary area, and the effect upon the water, of pollution from these cities and towns.

Owing to the increase in water consumption by growing cities and the advisability of maintaining natural sources of water supply as free of pollution as possible, all urban centres are obliged to consider a sanitary disposal of their wastes, especially sewage.

The solution of the problem has been more urgent in foreign cities than in our own country, owing to the increase in population and the small size of the streams, and has been the subject of investigation principally in New England and in the cities in the Eastern portion of the Country.

The relation of sewage disposal to water supply is an intimate one, and as it is impracticable to prevent all pollution, those communities, the water supply of which is affected by pollution, have been constrained to treat the drinking water.

The benefits to be derived from the installation of a water purification system are apparent in examining the decreased death rate in cities where such an installation has been made, as compared with prior conditions in the same cities or with that of other cities where the treatment is not as effecient. Some of the decrease however, may be due to better sewage disposal and rigid sanitary arrangements. The sources of diseases of the intestines have been traced in a large proportion of cases to the existence of sewage in untreated drinking water, therefore, the death rate from these diseases is regarded as an index of the danger from infection.

Decreased Death Rates from Typhoid Fever in Various Cities, Due to Treatment of Water Supply.

Philadelphia.

The death rate from typhoid fever in Philadelphia for ten years prior to the partial introduction of filtered water in 1902 averaged 41.5 per 100,000. There was an increase after the introduction of a partially filtered supply but at present with 85% of the total supply filtered, the rate has declined to 14 per 100,000.

Cincinnati, Ohio.

The death rate from typhoid fever in Cincinnati, Ohio, for 10 years before the introduction of filtered water in 1908 was 51 per 100,000 persons and after filtration in 1910 it was 5.7.

Hamburg.

As a notable example of a decreased death rate due to the installation of a water treatment works where the supply was sewage polluted, Hamburg Germany, may be mentioned. The death rate from typhoid fever prior to

1893, before the filtration of the Elbe river water was 47 per 100,000 persons, whereas after the introduction of the same water filtered, the rate declined to an average of about 7 per 100,000, and at present is about 4.0.

American and European Cities Compared as to Death Rates Due to Typhoid Fever.

From the report of the Metropolitan Sewage Commission of New York on Sewage disposal of the metropolitan district it appears that the average death rate from typhoid fever of twelve of the largest American cities for ten years 1898 to 1907 has been 54 per 100,000, while that of New York alone is much below the average, being 18 per 100,000 during the same period, and that of Philadelphia at present being 14.0

Of five of the larger Eurpoean cities, the average rate for the same period has been 7.6, the average for London has been 11.5, Paris 13.1, Berlin 4.2, Vienna 4.8, and Dresden 4.7.

It has been stated that in other German Cities, Munich and Bremen, the death rate is also very low, and in the former, the occurrence of a case of typhoid fever is exceptional.

Proportions of Treatment: Water Supply and Sewage Disposal.

While the results given are not conclusive as to the relative proportions due to treatment of the water supply and to the establishment of sewage disposal works, they appear to establish a relation which gives rise to the query: in treatment of both sewage and water supply, what is the economical balance of treatment and proportions of cost advisable to allow as between water supply treatment and sewage disposal?

It is recognized that there is a limit to the use of rivers as a means of sewage disposal without treatment, but as to how far the treatment of sewage should be carried before being discharged into the rivers is an economical problem of great importance, and should be studied in the light of results obtained under various conditions in other cities.

Factors of the Problem.

The problem then consists in a careful study of the local conditions

and inquiry into the best method of collecting the sewage, the number and character of extensions to be made to the existing sewer system to adapt it to the comprehensive plan, the choice of location and the design of pumping stations, the method of treatment and disposal to be adopted, the choice of locations and the design of disposal works, and the constructions of the works in such a way as to allow for the necessary expansion due to increase in population. Also the determination as to whether separate or combined sewers should be built, as to the amount of hourly fluctuation of dry weather flow, the amount of ground water and storm water for which provision must be made, and the design of automatic control apparatus and of tide gates to sewer outfalls. Lastly, the recommendations should deal with the economic feature of how far a city is justified in treating its sewage, taking into consideration the demands for pavements, schools, water supply, police and fire protection, lighting, parks, street improvements and other important municipal works.

Chapter V..

THE ESTABLISHMENT OF A TESTING STATION AND RESULTS OBTAINED

Preliminary Steps.

After the authorization of the investigation and the appropriation of funds to the Bureau of Surveys, it was arranged to establish an experimental sewage testing station with a view to examining into the availability for the treatment of local sewage of the various methods of treatment which have been in use in different cities of the world,

Testing Station.

After altering the testing station formerly used for experiments upon water purification at 33rd and Thompson streets, experimental work was begun on March 23, 1909 and discontinued May 15th, 1910. The sewage was that from the main intercepting sewer along the Schuylkill River, which, based upon analyses of samples from sewers in various parts of the City, was found to be generally typical

of the character of the City's sewage which could reasonably be expected to be delivered to a sewage works. It was concluded that processes which would be found satisfactory for this sewage, would give equally good results in the future.

Processes Examined.

As a result of the observations made by the officers of the City, it was decided to disregard the septic treatment entirely, and to experiment with such treatments as would deal with the sewage before septic action had taken place.

There were examined therefore, processes as follows: Crude sewage submitted to fine mesh screening, treated with hypo - chlorite of lime and dilution with river water, also sewage submitted to various periods of sedimentation in tanks of different types, and then submitted to bacterial processes, such as slate beds, contact beds, percolating filters of different classes and depths of material, the sewage applied by different devices for distribution, also applied to different special devices, for the study of comparative efficiency. In addition, the matter of sludge treatment and disposal received much attention.

For convenience the processes were designated as follows:- Preparatory, oxydizing, finishing processes; disinfection and dilution.

RESULTS OBTAINED AT TESTING STATION.

As a result of the work, the following conclusions were reached which are quoted from the printed report.

"SUMMARY OF CONCLUSIONS.

FINE MESH SCREENING.

The 35 mesh per inch screen removed one-third of the suspended matter in the crude sewage as applied; prevented the formation of scum in subsequent sedimentation tanks, and prevented the clogging of nozzle orifices on the sprinkling filters.

SEDIMENTATION.

For the purpose of comparison, the results of sedimentation are given in percentage removal, although it is recognized that effluents which are produced with equal percentage removal are not comparable on the basis of solids content.

Horizontal Flow.

Three and one-half hours nominal flow through a baffled sedimentation tank removed two-thirds of the suspended solids in the crude sewage; an increased storage did not produce a proportionate improvement in the efficiency of the tank. Baffling by equalizing velocity through the cross section prevented dead spots in the tank and restrained sludge and scum at the inlet end.

Between periods of three and a half to six hours flow the influent was not deoxidized nor rendered offensive when sprayed upon sprinkling filters. To prevent septic action the tanks required sludging and washing out every six weeks.

Vertical Flow.

The Emscher or Imhoff tank studied illustrated the principle involved, inasmuch as the substantial separation of the sewage flow from the digesting sludge keeps the sewage fresh and eliminates offensive odors either in the effluent, the sludge, or in the gas developed.

The removal of suspended solids from the crude sewage was but little more than one-half due to the shallowness of the tank; the efficiency may be increased in tanks of working size.

SLATE CONTACT BEDS.

The best results were accomplished when this bed was filled twice a day, or at a rate of two million gallons per acre per day.

Crude sewage applied, deposited three-fourths of the suspended solids; the effluent was slightly nitrified and rendered partially stable.

The deposit on the slates was inodorous, resembling earth, and could be removed by flushing in the small size bed experimented with.

Where slates are not a waste product the construction of the bed would be costly.

CONTACT SYSTEM.

The primary and secondary beds treating settled sewage did not mature sufficiently to yield a stable effluent although it was very low in suspended matter. The highest rate obtained was 1,350,000 gallons per acre per day. With sewage containing less trade waste better results might have been obtained.

SPRINKLING FILTERS.

Distribution.

Best results were obtained with fixed sprinkler nozzles when the film of sewage was made to constantly travel back and forth over the media, without a resting period; this caused a uniform rate of flow from the underdrains.

Rate of Operation.

A regular uniform rate of operation produced better results than the same net rate obtained irregularly. With filters exposed to the weather and receiving sewage partially settled, the maximum rate obtained was two and a half million gallons per acre per day, but in the Winter the stability of the effluent deteriorated.

With a filter protected from the weather, having fine screened and settled sewage uniformly distributed over its surface, and having a ventilating system, the maximum rate used was three and one tenth million gallons per acre per day. The effluent was practically always stable. How far this whould have been affected by exposure to the weather was not determined.

Kind of Media.

Trap and gravel maintained their initial size. Linestone and slag disintegrated to a slight extent.

The smooth surface of the gravel stones was not as well adapted to the formation of a bacterial jelly as rougher media, and the extreme roughness of slag caused it to retain the deposited solids.

The rough, irregular cinders removed all the suspended matter from coarsely screened sewage, so that clogging soon ruined the bed.

Size of Media.

The completeness of preliminary treatment partially controls the size of media in subsequent filtration.

In filters exposed to the weather and receiving sewage partially settled, operating at two and a half million gallons per acre per day, best results were obtained from trap media one inch to three inches in size. Under the more favorable conditions of fine screened and settled sewage as an influent uniformly distributed, at a rate of three and one-tenth million gallons per acre per day, media three-quarters inch to one and a half inch produced an excellent effluent.

Depth of Bed.

Filters of less depth than six feet were not satisfactory, but from filters six feet or more in depth effluents could be obtained at rates between two and a half and three million gallons per acre per day of satisfactory quality. The additional depth over six and one-half feet did not seem to be economical.

Maturing.

Filters exposed to the weather, receiving sewage partially settled, and put in operation in March, yielded a satisfactory effluent in three weeks and after three months the effluent was perfectly stable.

A filter protected from the weather, having fine screened and settled sewage uniformly distributed over its surface and put in operation in July, yielded a perfectly stable effluent after one week of service.

Unloading.

In filters operated at rates between two and one-half and three million gallons per acre per day, media composed of stones approximately uniform in size completely unloaded the solids stored up in the interstices, whereas media composed of stones of great diversity in size became badly clogged but did not unload.

Effect of Freezing Temperature.

No trouble was experienced from the formation of ice upon the surface of the filters; biological activity was decreased by the low temperature to such an extent, however, that at a rate of two and one-half million gallons per acre per day the fine grain and graded mixture beds pooled and the effluents of all the exposed filters were of lower stability than in summer.

Elimination of Surface Growth.

Fungus growths on the surface were completely removed by an application of calcium hypochlorite dissolved in water.

The continual disinfection with calcium hypochlorite of the influent to a filter maintained its surface in perfect condition and did not interfere with the biological action of the bed.

Bacterial Efficiency.

The average number of bacteria in the effluent of a mature sprinkling filter operated at rates between two and one-half and three million gallons per acre per day was 400,000 per c.c., which represented a removal of 86 per cent from the crude sewage.

Bacterial efficiency within a limited range of small size stone was proportional to depth of bed.

Settlement of the Effluent.

When the effluent was passed through a settling basin in two hours much improvement was obtained by the removal of the suspended matter.

HAMBURG AND INTERMITTENT SAND FILTER.

A filter modeled after the so-called Hamburg type, in which distribution is effected by a layer of fine coke; also a shallow, coarse size sand filter both operated at too low a rate to be economical, for the conditions in Philadelphia.

DISINFECTION.

Fresh sewage from which suspended matter larger than one-twenty-fifth inch had been removed was disinfected to a practical degree with calcium hypochlorite; the amount of disinfectant required depended upon the amount and condition of the organic matter in the sewage.

Economy of design and operation can be attained by short storage and mechanical agitation to insure contact of the disinfectant and the sewage.

DILUTION.

Crude sewage when passed through a fine mesh screen or satisfactorily settled to remove the solids larger than 1-25 inch, and disinfected with calcium hypochlorite to yield six parts per million available chlorine; was added to river water in proportions up to one to ten, and its purification accomplished without offense to sight or smell nor the depletion of the dissolved oxygen of the river water below 50 per cent saturation.

SLUDGE.

Amount

Horizontal flow in sedimentation tanks produced sludge 88 per cent moisture at an average rate of five cubic yards per million gallons sewage.

An Emscher tank with 4½ feet vertical flow produced sludge 82.6 per cent moisture at an average rate of nine-tenths cubic yards per million gallons sewage.

Condition.

Cleaning plain sedimentation tanks caused considerable offense, but the sludge withdrawn from the Emscher tank had a tarry odor and was not

offensive.

Scum formed on sedimentation tanks except when the influent was screened.

Digestion.

The placing of sludge from a sedimentation tank in a water tight, uncovered tank for digestion did not prove successful.

Lagooning.

Wet sludge from plain sedimentation tanks placed in earth lagoons to a depth of twelve inches in moderate weather, dried to a consistency fit to remove within the six weeks elapsing between cleaning tanks, and its volume was four-tenths of that applied.

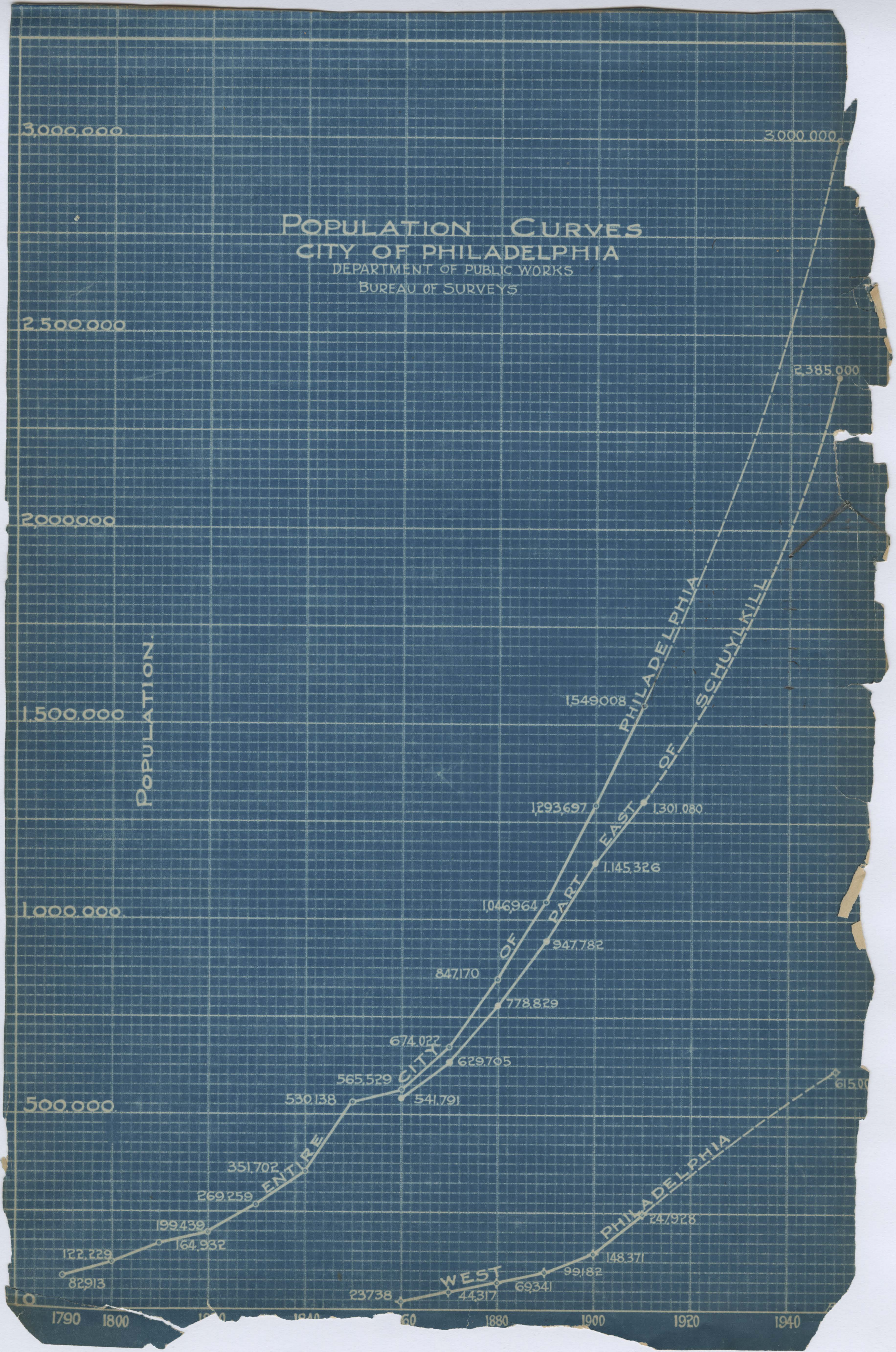
Sludge Bed.

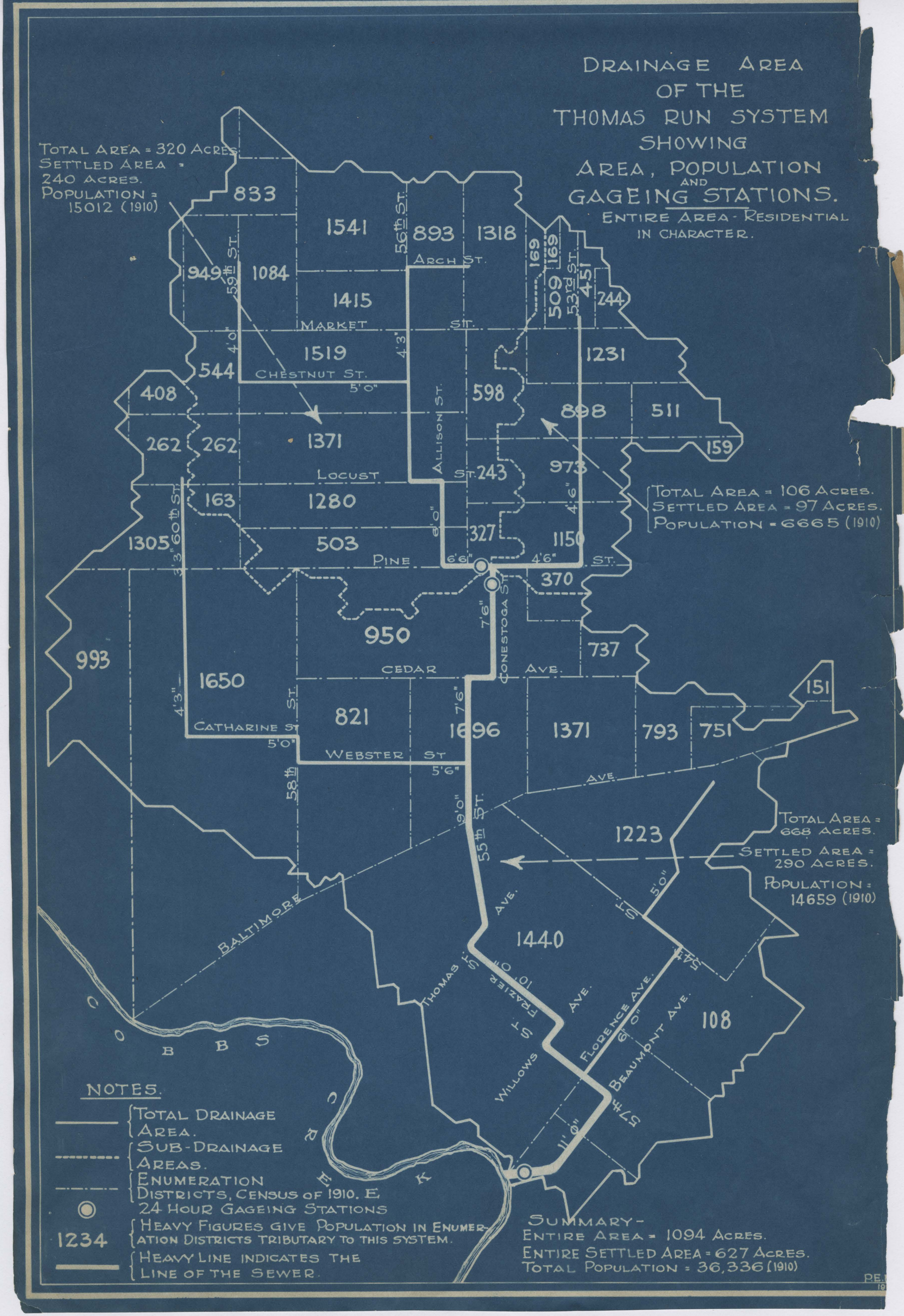
Fine sand or sawdust over a coarse stone drainage floor was more efficient for reducing moisture in sludge than a plain earth lagoon

Wet sludge from a sedimentation tank, applied six inches deep in winter weather, under cover, dried to a consistency fit to remove in six days and under the same conditions but not under cover, in twelve days.

Based upon small size tests in winter weather, Emscher sludge 12 inches deep upon a sand bed, dried to a consistency fit to remove in 12 days during freezing weather. In Germany the time is given as from 4 to 5 days, but sludge is not withdrawn in freezing weather which accounts for the difference.

When equal weights of rice coal and wet sludge were mixed and placed on sludge beds, the mixture was fit to remove in one day, and was successfully burnt."

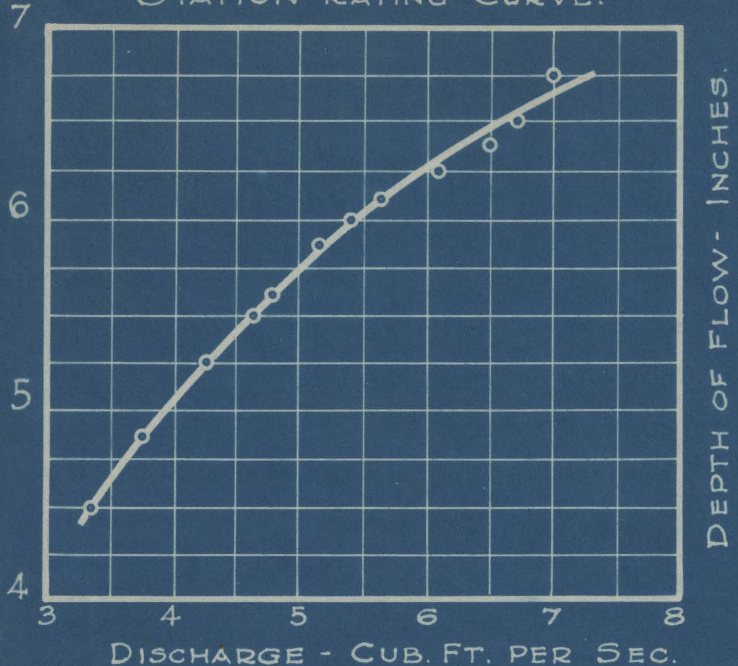

POPULATION CURVES
CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS
POPULATION.
3,000,000.
2,500,000
2,000,000
1,500,000
1,000,000.
500,000
0
3,000,000
2,385,000
615,00
ENTIRE CITY OF PHILADELPHIA
PART EAST OF SCHUYLKILL
WEST PHILADELPHIA
82,913
122,229
199,439
164,932
269,259
351,702
530,138
565,529
541,791
674,022
629,705
847,170
778,829
1,046,964
947,782
1,293,697
1,145,326
1,301,080
1,549,008
23,738
44,317
69,341
99,182
148,371
247,928
1790
1800
1880
1900
1920
1940


DRAINAGE AREA
OF THE
THOMAS RUN SYSTEM
SHOWING
AREA, POPULATION
AND
GAGEING STATIONS.
ENTIRE AREA - RESIDENTIAL
IN CHARACTER.
TOTAL AREA = 320 ACRES.
SETTLED AREA = 240 ACRES.
POPULATION = 15012 (1910)
TOTAL AREA = 106 ACRES.
SETTLED AREA = 97 ACRES.
POPULATION = 6665 (1910)
TOTAL AREA = 668 ACRES.
SETTLED AREA = 290 ACRES.
POPULATION = 14659 (1910)
833
1541
893
1318
169
169
949
1084
1415
509
451
244
1519
1231
544
408
598
898
511
262
262
1371
159
243
973
163
1280
327
1150
1305
503
370
950
993
737
1650
821
1696
1371
793
751
151
1223
1440
108
ARCH ST.
56th ST.
59th ST.
53rd ST.
MARKET ST.
CHESTNUT ST.
ALLISON ST.
LOCUST ST.
60th ST.
PINE ST.
CONESTOGA ST.
CEDAR AVE.
CATHARINE ST.
58th ST.
WEBSTER ST.
BALTIMORE AVE.
55th ST.
THOMAS ST.
FRAZIER ST.
WILLOWS AVE.
FLORENCE AVE.
BEAUMONT AVE.
54th ST.
57th ST.
COBBS CREEK
4'0"
4'3"
5'0"
6'0"
6'6"
4'6"
4'6"
7'6"
3'3"
4'3"
7'6"
5'0"
5'6"
9'0"
5'0"
10'0"
6'0"
11'0"
NOTES.
TOTAL DRAINAGE AREA.
SUB-DRAINAGE AREAS.
ENUMERATION DISTRICTS, CENSUS OF 1910. E
24 HOUR GAGEING STATIONS
1234
HEAVY FIGURES GIVE POPULATION IN ENUMERATION DISTRICTS TRIBUTARY TO THIS SYSTEM.
HEAVY LINE INDICATES THE LINE OF THE SEWER.
SUMMARY -
ENTIRE AREA = 1094 ACRES.
ENTIRE SETTLED AREA = 627 ACRES.
TOTAL POPULATION = 36,336 (1910)
P.E.

Results of Gageings of the Dry Weather Flow in Thomas Run Sewer

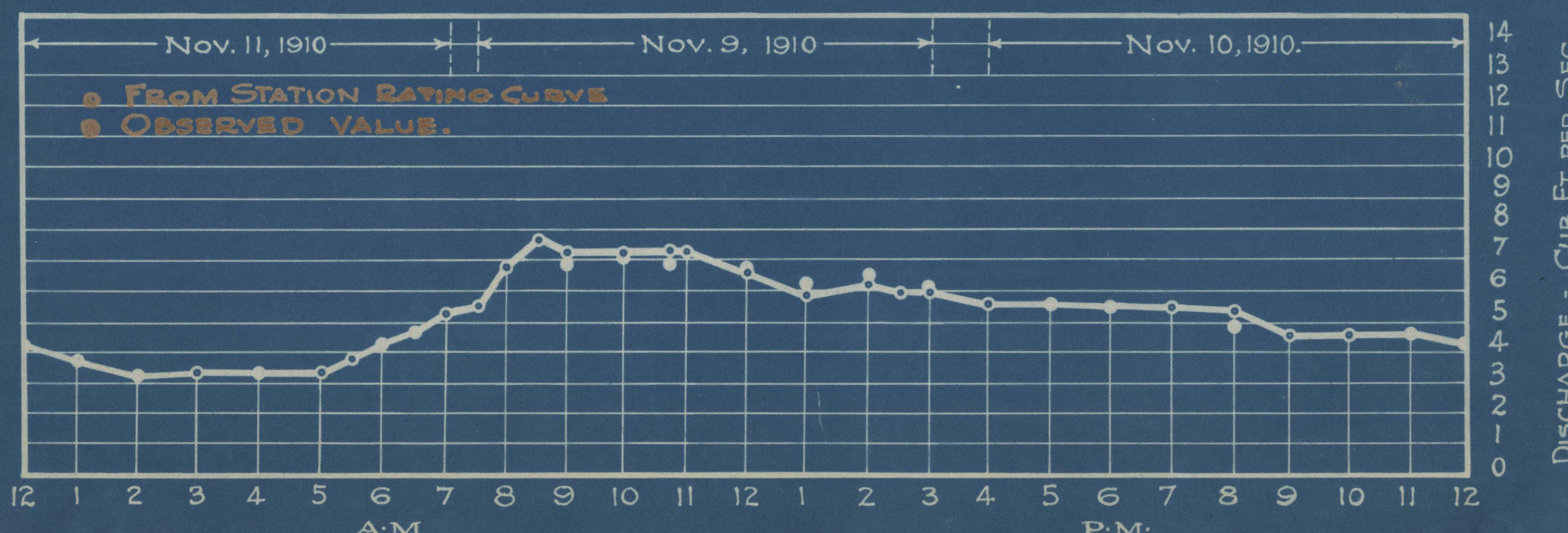
Gaged on Conestoga St. 250 Ft. South of Pine St.

Station Rating Curve.



Area in Acres		Population Census 1910.		Average Discharge per 24 Hrs.					
				Gallons per Day.			Cubic Feet per Sec'd.		
Total	Settled.	Total	Per Settled Acre	Total	Per Settled Acre	Per Capita	Total	Per Settled Acre	Per Capita.
426	337	21677	64	3,320,000	9860	153	5.14	.0153	.00024

Average Depth of Flow = .064 Diameter.



P.E.M.
1911.

SUMMARY of DATA

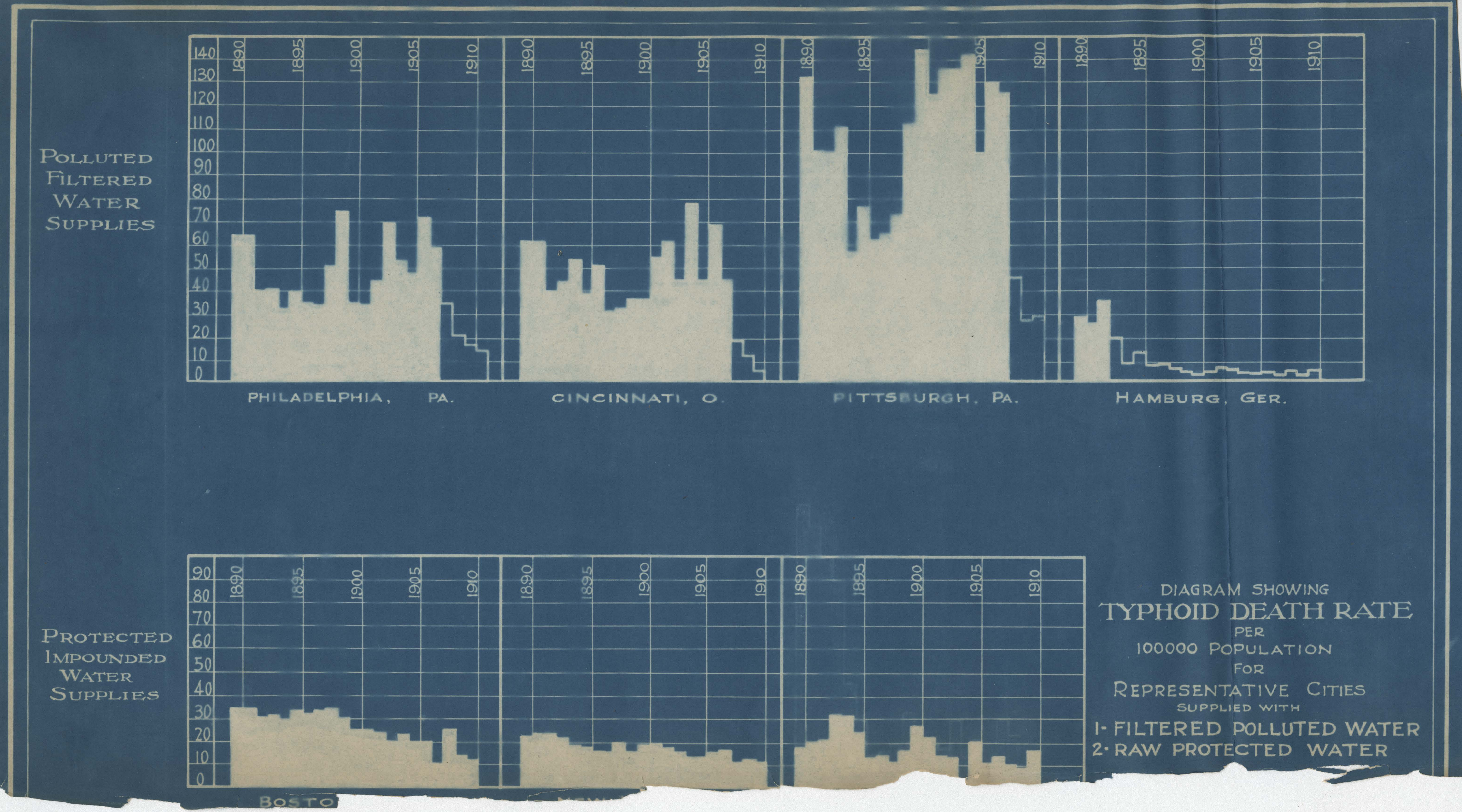
Obtained from Gaugings of Dry Weather Flow made in 1910.

Name of Area	Character	Point Gauged	Area in Acres: Total	Area in Acres: Settled 1910	Population Census 1910: Total	Population Census 1910: Per Settled Acre	Average Discharge per 24 Hours: Gallons per Day: Total	Gallons per Day: Per Settled Acre	Gallons per Day: Per Capita	Cu. Ft. per Sec.: Total	Cu. Ft. per Sec.: Per Settled Acre	Cu. Ft. per Sec.: Per Capita	Depth of Flow / Diam. of Sewer
THOMAS RUN	Residential Mostly pairs of two and three story houses.	Pine St. W. of Conestoga	320	240	15012	**62.5**	3,410,000	14200	**227**	5.26	.0220	.000350	.088
		Conestoga St. S. of Pine	426	337	21677	**64**	3,320,000	9860	**153**	5.14	.0153	.000237	.064
		Outlet at Cobbs Creek	1094	627	36336	**58**	6,175,000	9850	**170**	9.6	.0153	.000265	.066
PINE ST.	Residential Mostly solid four to six story houses.	Pine St. Between 25th and 26th Sts.	160	156	15152	**97**	4,105,000	26300	**271**	6.35	.0407	.000419	.093
SHUNK STREET	Residential Mostly rows of two and three story houses	Shunk St. at Bancroft	208	208	25754	**123**	2,190,000	10500	**85**	3.39	.0163	.000132	.128
		Shunk St. W. of 18th St.	331	331	37916	**114**	3,516,000	10600	**93**	5.44	.0164	.000143	.106
LOMBARD ST.	Residential Tenements and hotels.	Lombard St. at 3rd St.	147	145	16363	**113**	5,030,000	34750	**308**	7.78	.0536	.000475	.114
YORK ST.	Residential and Manufacturing	York St. at Cedar St.	358	354	33340	**94**	12,754,000	36000	**383**	19.7	.0556	.000591	.120
MARKET STREET	Commercial	South side W. of Strawberry St.	58	36*	The population contributing sewage is not shown by the census figures.		3,547,800	99250		5.5	.1534		↔ .135
		North side at Bank St.	123	80*			7,608,000	92800		11.8	.1435		↔ .156

* This area is practically entirely built up; the settled area is "total" minus "street area".

↔ Equivalent ratio in a circular sewer.

W L Stevenson



Polluted Filtered Water Supplies
Protected Impounded Water Supplies
Philadelphia, Pa.
Cincinnati, O.
Pittsburgh, Pa.
Hamburg, Ger.
1890
1895
1900
1905
1910
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Diagram showing
Typhoid Death Rate
per
100000 Population
For
Representative Cities
supplied with
1- Filtered Polluted Water
2- Raw Protected Water

CHAPTER VI

POPULATION DATA.

Methods Described.

As a preliminary in the study of any plan of sewage collection and disposal, the first essential was to determine the population, present and future, as near as may be, not only of the city as a whole but by wards, districts and drainage areas. To this end there was collated from the census reports from 1790 to date the population of the city and since 1860 of the various wards or districts, interpolations being made for portions of decades where changes in ward boundaries had taken place. After this information was collated, curves representing the growth of population in each of the wards of the City were prepared.

In order to understand these population growths beyond the present the type of improvement and the percentages of increase or decrease in a ward or in groups of wards were taken into consideration, and curves governed by the percentages of increase by decades were plotted and the sum of the future estimated population in the City which gives a factor of safety to allow for the shifting of centers of improvement..

This preliminary work having been done it was then necessary to take up the population of the various drainage areas tributary to the larger or main sewers, to determine the present population and from the curves above mentioned, the future estimated population within each; after which tables were prepared showing these results for 1910 and 1950, which year was taken as the limit of inquiry in the problem.

The curve for the whole City determined as above described, indicates that in 1950 its population will be about 3,000,000.

Tables of Population.

The population of the city divided into the various large drainage areas tributary to the pumping stations may be seen by reference to table under the chapter on "Sewers and Design of Sewage Collectors".

Chapter VII

GAUGINGS OF SEWERS AND DESIGN OF SEWAGE COLLECTORS.

The population from the census of 1910 and estimated population for 1950 upon the various main drainage areas having been determined and also those tributary to the smaller sub-areas, the next step was to determine the sewage flow from a number of typical built up drainage areas in order to apply a "per capita flow" factor to undeveloped areas, which could be considered to reach a future development similar in character and density of population to those where gaugings were taken.

Methods Used.

A typical drainage area having been determined upon and a gauging station selected, a corps of men, by means of a velocity meter and by measurements of grades, depth of flow and sectional area of the flow in the sewer, the observations being taken when not influenced by rainfall or drought at intervals during every one of twenty-four hours, determined the daily maximum, minimum and average flow in the sewer.

The population being known, the settled or built up area was calculated, and from these the average daily discharge both per settled acre and per capita were determined.

The results were obtained in gallons per day for use in designing works and in cubic feet per second for use in designing collecting sewers.

Application of Factor.

In order to determine the volume of sewage to provide for from an unimproved territory, its possibilities in the way of development were fixed in the judgements of the officials and it was given its place in its class; whether of closely built residences, urban, suburban, semi-suburban, together with its proportion of manufacturing industries.

This having been determined for each main area and subarea, then using the estimated population of each, the factor of sewage flow was applied corresponding to that of the flow determined from the gauging of an area most resembling in the nature of its development, the area in question.

This method is considered an improvement over the practice of assuming a population at a uniform rate over large areas, and then applying a uniform rate of sewage flow.

Gaugings applied to Designing Collectors.

The influence of the gaugings of sewers in sections of various types of development, upon the design of collectors may be seen in the following description of method of collecting data for the design of intercepting or collecting sewers.

Upon the watershed of a certain main sewers, the population of each tributary area, both present and future having been determined, a factor of per capita sewage flow is applied from the gauging of a built up section, having a population per acre and character of development approximating to the calculated population and manner of development of the area under investigation.

The product of the estimated population and the flow factor will give the average daily flow from each of the tributary areas.

The gaugings show a daily fluctuation, the daily maximum being useful in the design of works. In addition to providing for the daily maximum, which includes ground water, provision must be made for the admission of a certain margin of increased flow during the early part of storms.

The intercepting sewers were designed to carry a sufficient quantity of this increased flow during storms, so that the portion which will be carried out into the streams will be extremely so diluted as to give rise to no complaint.

English and American Sewage Compared with Relation to their Dilution.

The usual requirements of the Local Government Board of England were that storm water in sewage up to three times the normal dry weather rate should be dealt with by the ordinary disposal plant, and that special storm water filters should treat an additional amount up to six times the dry weather flow before discharging into the streams.

Inasmuch as the number of gallons of water used per day in various

cities of England averages between 30 and 40 per capita (34 in London), and as the amount of water used in Philadelphia per capita is approximately 200 gallons, and as it is known from experience, that the solids produced are practically uniform for all countries, it is readily seen that the fresh sewage of Philadelphia is equivalent to the ordinary English sewage diluted with storm water to about six times its volume.

If, therefore, at times of storm, the excess of local sewage over the dry weather flow is allowed to go into a stream, it is equally as dilute as English sewage to which is added 5 times the volume of storm water.

Therefore, in designing collectors for this City, not only the dry weather flow of the sewage, but an additional percentage from the first flush of the storms was provided for. From the fact that the sewers are not expected to run full under these conditions, a considerable excess of this storm flow could readily enter the intercepting sewers before the overflows into the adjacent streams would be called into play.

Amount of Sewage.

North East Station.

The methods described in the forgoing paragraphs were followed in determining the total amount of sewage, together with the daily fluctuation, also that due to storm. The result is shown in the following tables:--

		From Somerset St.	From Frankford Creek	From Somerset & Frankford Creek	From Torresdale	Total
		Million Gallons per day	Million Gallons per day	Million Gallons per day	Million Gallons per day	Million Gallons per day
1910	Average	37.4	34.9	72.2	22.2	
	Daily Min.	29.1	27.2	56.2	17.3	
	Daily Max.	47.8	44.6	92.4	28.4	
	Storm Max.	52.5	49.1	101.7	31.3	
1950	Average	51.5	94.7	152.2	35.4	187.6
	Daily Min.	44.9	73.6	118.5	27.7	146.0
	Daily Max.	73.5	120.8	194.3	45.4	240.0
	Storm Max.	81.4	133.0	214.4	50.0	264.0
POPULATION	1910	177,080	137,478	314,558	22,078	336,636
	1950	345,390	514,740	860,130	43,864	903,994

Penrose Ferry Station

The same methods produced at the Penrose Ferry Station, the results shown on the following table:

		From Delaware River	From East Bank Schuylkill	From West Bank Schuylkill	From Cobbs Creek *	Total
		Million Gallons per day	Million Gallons per day	Million Gallons per day	Million Gallons per day	Million Gallons per day
1910	Average	174.1	80.3	45.4	29.7	309.5
	Daily Min.	136.4	62.6	35.4	7.6	242.0
	Daily Max.	222.8	102.8	58.7	12.4	396.7
	Storm Max.	246.1	113.1	64.2	13.6	437.0
1950	Average	221.0	151.9	105.8 †	28.4	508.1
	Daily Min.	172.0	118.2	82.8	22.2	395.2
	Daily Max.	282.2	194.3	136.4	36.4	649.3
	Storm Max.	311.0	214.0	150.3	40.2	715.5
POPULATION	1910	687,586	273,179	180,811	67,005	1,208,581
	1950	887,212	593,543	475,202	140,348	2,096,305

* Population shows number of persons on drainage areas, but not necessarily tributary to the sewers.

† Contains 40th Ward Low land(33) 31

Chapter VIII

COMPARISON OF METHODS OF SEWAGE DISPOSAL

In the study of the most available plan for use in the City of Philadelphia, the principle was adopted of considering in a preliminary way, every practicable scheme, comparing them and by processes of elimination reducing the number for final discussion and choice. A number of plans were rejected upon superficial inspection, the processes and reasons therefore being as follows:

Land Irrigation.

This was not considered suitable for local conditions for the reason that there was not sufficient land within the limits of the City of Philadelphia available for the purpose. The character of the land available was not suitable, its cost would be prohibitive, and the slowness with which the method could be operated, under most favorable conditions, made it objectionable and further, as the experience of the cities having large treatment areas of this kind is that there is no money value in sewage for irrigation purposes, no return from this source can be counted upon.

Chemical Precipitation.

This system which is in use in many cities of England, does not give satisfactory results, and the effluent from works is frequently objected to by the Conservency Boards having charge of these matters. The amount of sludge resulting from this method is so great that it makes the problem of removal and disposal of this one item a very serious one. In addition to this, the cost of chemicals is very considerable and its economic value remains to be proved.

Septic Tanks.

These tanks may be described as large covered or uncovered reservoirs, through which the sewage flows, remaining therein for from 8 to 24 hours in accordance with the local conditions, during which time the matter in suspension is deposited, the deposit being called sludge, which by bacterial action is considerably reduced in volume, Although a considerable

number of English purification plants and a large number of American have the septic tanks in use, the claims made for them originally have not been fully realized, in fact the experience with them has been unsatisfactory as far as the amount of digestion of the sludge is concerned. In addition a tank of this character on account of the odors produced constitutes the main feature of objection to sewage disposal installations on the part of adjacent property owners.

Experience in England

A summary of the results obtained by the septic tank may be best illustrated from an Editorial in the London "Engineering" of March 13, 1908.

> "Sewage sludge is the despair of the sanitarian. Some ten years ago we were told that it was about to disappear, and that it would trouble us no more. The obliging microbe was going to digest it for us, in return for our providing it free quarters in a septic tank. Practically nothing would remain except liquid sewage, which could be confided to the care of another kind of microbe in a bacterial filter. -----Instead of consuming 95 per cent. of the solids in sewage, it is satiated with 30 per cent. and often, indeed, it is content with 10 per cent. and leaves the other 90 per cent. to plague the engineer in charge of the work."

Contact Beds.

Many of the modern sewage disposal plants in both England and America depend upon contact beds in part for purifying the sewage. These are practically filters composed of broken stone, brick, coke or cinders generally from two to five feet in depth, upon which sewage is discharged, allowed to stand a short time, then drawn off and thoroughly ventilated before adding another dose. From the fact that the greatest rapidity with which these beds can be operated is about 500,000 gallons per acre per day under the most favorable conditions, it is undesirable for the same reasons that apply to land irrigation. The method of construction also is such as to require constant cleaning and rebuilding after a period of years.

Chapter IX.

PRELIMINARY PLANS

In the study of the question, preliminary plans and estimates were prepared based upon a number of combinations of disposal works together with the necessary intercepting sewer collectors including also the approximate cost of maintenance. These plans were divided into three groups as follows:

1. Treatment at one plant

11. Treatment at two plants

111. Treatment for sewage from the Schuylkill basin, and reducing the suspended solids in the sewage going directly into the Delaware river.

Under group 1, there were three subdivisions by which the use of the combined and the separate systems were compared.

Under group 11, there were four subdivisions considered, comprising various arrangements of intercepting sewers and treating differing portions at each of the plants.

Under group 111, there were five studies considered, all dealing with various suggested methods of partial treatment of the sewage now going directly into the Delaware river, and refined treatment for that going to the Schuylkill river.

Choice of a Preferred Plan.

After careful examination and discussion of the preliminary estimates by the Director of the Department of Public Works, the Engineers of the City and the Consulting Engineer, the plans included in group one, for all sewage to be conducted to one disposal works, by the use of either the combined or separate system, were rejected on account of their cost, lack of elasticity and their magnitude as compared with other plans.

The estimated cost of ~~these two~~ the combined and the separate systems as applied to the local case, effectually eliminated the separate system, in as much as the difficulty of construction in streets occupied by underground structures,

together with the great cost of repaving streets would require an expenditure of about twenty millions of dollars more that would be required under combined systems.

An additional sum of about thirty four millions of dollars would be required to make the plumbing alterations to conform to the separate system in the 450,000 buildings estimated to be connected with the sewers when the work would be undertaken, an expense which would devolve upon the city.

In view of this great excess of cost of the separate over the combined system, in considering the other groups, the estimates were based on the combined system only.

It must be borne in mind, however, that in undeveloped sections, where new sewer systems can be installed, the separate system of sewers is being provided for in order to lessen the quantity of sewage which would otherwise reach the works.

The plans in group three were rejected on account of the great cost, considering their temporary nature and the probability of low efficiency in the future.

The plans in group two providing for all sewage to be treated at two disposal works, were selected for final consideration, because they were expected to accomplish the desired results at a lower cost.

Description of the Preferred Plan.

Of these plans, the one which was preferred may be described as providing for collecting the sewage at two points of disposal, one in the Northeasterly section of the City in the vicinity of Frankford Creek, and the other in the low lands of the 40th Ward, with intercepting sewers on the east and west banks of the Schuylkill river, and also on the Delaware river, North and South of Dyott Street or Aramingo canal and also adjacent to the larger inland creeks. The plan was chosen because of its elasticity, as it would allow of the construction of intercepting sewers from time to time and the enlargement

of the disposal works as necessity required.

Discussion of the Preferred Plan.

The general outline of a feasible preferred plan for the City of Philadelphia as given above was chosen on comparative data only, from the standpoint of a city of 3,000,000 of population with the needs of a city of such size, and left open until additional data could be secured, the discussion of the economical aspects of the problem and the possible modification of the plan in which the sewage would be collected and after screening and sedimentation as preliminary treatment that it then be allowed to flow into the Delaware river, provided examination would show that this could be done without reducing the amount of dissolved oxygen of the river below an allowable limit.

To this end examinations of the Delaware river have been made and compared with the conditions which exist in other large cities of the world having similar natural advantages for this method of disposal.

Chapter X.

SEWAGE DISPOSAL BY DILUTION.

Most of the Cities of Germany located upon rivers of sufficient large size collect the sewage at one or more central stations, pass it through grit chambers, screen it and discharge it directly into the rivers, the large volumes of which in most cases dilute the sewage to such a degree that it becomes unobjectionable, or at least sufficiently so, to receive the approval of the river officials charged with their supervision. The same is true of English cities where located upon estuaries or large rivers.

At the present time the treatment of crude sewage by dilution is the system of disposal in use in the City of Philadelphia. The large volume of flow in the Delaware river passing by the City presents as favorable an opportunity for the dilution method of disposal to the extent of its feasibility as that of any other city in the country, or abroad. When it is taken into consideration that the sixteen largest cities of the world, having a population of over 1,000,000 inhabitants each (with three exceptions, where the conditions are unfavorable) utilize the large volume of water passing by them as a method of final disposal, and most of them with entire satisfaction, it is evident, that any plan adopted by this city for disposal must be in part a dilution plan, if precedent has any value and if economic features are taken into consideration, and advantage be taken of natural conditions, favorable for such a means of disposal.

Illustrations of Relation between Sewage Disposal, Water Supply and Public Health.

The protection to the public health from water borne diseases by properly designed and operated water purification works has been clearly demonstrated by examples in Europe and America, where water supplies are taken from polluted sources and purified before delivery to the consumer.

As illustration of this, it is pertinent to examine into the conditions which exist in various cities where rivers are carrying sewage

either crude or partially purified. First in the hygienic aspect and second from the point of view of creation of a nuisance.

TABLES OF TYPHOID FEVER DEATH RATES

PER 100,000 PERSONS

1890 - 1910

SHOWING COMPARISON BETWEEN PROTECTED IMPOUNDED WATER SUPPLIES AND POLLUTED FILTERED WATER SUPPLIES AS INDICATED BY PREVALENCE OF TYPHOID FEVER.

Note: The arrow indicates the date of beginning of improvement to the water supply.

YEAR	Protected Impounded Water Supplies			Water Supplies from Polluted Sources now Filtered.			
	New York	Boston	Worcester	Philadelphia	Cincinnati	Pittsburg	Hamburg
1890	22	34	17.7	64	62	132	27
91	23	34	20.4	64	62	100	24
92	23	30	20.9	40	40	100	34
93	22	31	32.6	41	44	111	→ 18
94	18	29	31.6	32	54	56	7
95	17	33	24.5	40	39	77	11
96	16	31	13.3	34	52	62	6
97	15	33	13.9	33	32	64	7
98	19	34	11.6	51	33	74	5
99	15	30	16.5	75	37	112	4
1900	18	25	27.1	35	37	144	3
01	19	25	21.5	34	55	124	4.2
02	18	24	14.5	44	62	134	5.2
03	15	20	13.4	69	45	134	4.3
04	13	23	3.8	53	79	142	3.9
05	13	20	19.7	48	45	99	2.8
06	15	20	11.1	72	69	130	3.8
07	16	10	13.1	→ 59	→ 45	125	2.7
08	11	25	10.0	35	19	→ 47	4.7
09	12	14	8.4	21	13	24.6	2.4
1910	11	12	15.7	17	5.7	27.7	5.3

Polluted Water Purified.

Hamburg.

The City of Hamburg is situated upon the bank of the Elbe river in Germany under geographical conditions very similar to Philadelphia.

The Elbe river is s tidal stream (6 feet range of tide) of fresh water having an average flow less than that of the Delaware river, but a little greater than the latter in time of extreme drought. Upon the

watershed of the Elbe, above the intake to the water filters, there are 46 large cities and it is estimated that the sewage of 5,900,000 persons reaches the river; the sewage of 1,700,000 is treated and that from the remaining 4,200,000 enters the river untreated.

The sewage of the City of Hamburg and environs, contributed by a population of 900,000 persons, is discharged into the river after coarse screening, 8½ miles down stream from the water intake. The river being tidal, this sewage affects the raw water reaching the filters.

Hamburg's water supply was Elbe river raw water until 1893 when the present filter plant was put in service. In diagram No. the typhoid death rate of Hamburg is shown. The adequate protection to the city afforded against this disease by filtering the polluted Elbe water may be clearly seen.

Altona

The City of Altona is situated on the Elbe river immediately adjoining Hamburg. The intake of the waterworks taking the supply from the river is 7 miles below the sewage outlets of Hamburg. The condition of the Elbe water at this intake must therefore be even more polluted than at the Hamburg intake. The water has been settled and doubly filtered since 1860 before delivery to the Altona consumers.

In 1892, before the introduction of filtered water in Hamburg, there occurred an epidemic of Cholera in this city, the sewage of which flowed past the intake of the Altona water supply. The citizens of Altona, having filtered water from the same source, were adequately protected against the scourge raging in the adjacent City.

Cincinnati, Ohio.

This city obtains its water supply from the Ohio river which receives and carries the raw sewage of Pittsburg, Wheeling, and other cities, having collectively a population of about 2,000,000 persons. When raw water was used, the intake was located in the heart of the city, many large

sewers entering the river above the intake. In 1908, the intake was located above the influence of the sewers of Cincinnati and the river water is now settled, coagulated, and filtered before delivery to the consumer. Upon the introduction of the filtered water, the typhoid death rate immediately dropped as shown in the diagram No.......notwithstanding the river is polluted as before stated.

Impounded Protected Water.

Boston

The water supply of Boston is obtained from Lake Cochituate, the Sudbury river, and the Nashua river. To improve the quality of the water and prevent its pollution, ditches have been constructed to drain swamps on the watershed; works for filtering water of objectionable quality before permitting it to enter the reservoirs have been constructed, and a constant and careful inspection of the watershed to prevent any possible pollution is conducted. Over 40,000 persons dwell upon the watershed of the Boston water supply, but every precaution is used to prevent their wastes from reaching the citizens of Boston through the water.

Worcester, Mass.

The water supply of Worcester is obtained by impounding in storage reservoirs the flow of three streams whose sheds are but sparsely inhabited; much of the area is owned by the city and all dwellings on the watershed are under sanitary inspection.

New York

The water supply of New York City is also obtained from an impounding reservoir. An idea of the precautions taken to prevent pollution may be obtained from recently published accounts of the complete disposal of wastes in construction camps now located upon the croton watershed.

Conclusions.

From an examination of the table and diagrams of typhoid death rates, it may be seen how effectively the public health, as related to typhoid fever, is improved by a filtered water supply. It may also be seen that a protected supply, while better than a raw water supply, is not as effective as a filtered supply, which is explained by the fact that the control of a filter plant is more readily accomplished than the control of a watershed. The City of New York, notwithstanding a fair protection of the Croton watershed, is now preparing to filter this supply.

It must be realized that the raw waters of the filtered supplies quoted are much more polluted than the protected supplies, and yet, yield more healthful water after filtration.

CAUSES OF NUISANCE IN RIVERS.

Nuisance to Sight.

The next matter for consideration is, what amount of sewage can be added to a river and not create a nuisance either to sight or smell, in short, what amount can be added and still keep a river clean.

When crude sewage is discharged into a river in large amounts, the foecal matter, paper, sticks, etc., by floating upon the surface of the water present an unsightly appearance. The river can no longer be considered clean.

Nuisance to Smell.

The existence of a nuisance to smell or the degree of objectionable odor, depends on the depletion of oxygen in the sewage and the natural substitution of a putrifactive process. The depletion is likely to take place after sewage is 6 to 12 hours old, depending on the dilution and the temperature. If sewage can be discharged, in a fresh condition, in proper proportions into a river, putrefaction and objectionable odors do not result.

When crude sewage is discharged into a river in a putrefying condition, it seizes upon the oxygen dissolved in the raw water and by

forming new compounds, removes it therefrom. When the oxygen becomes exhausted also in the river water, then the river becomes foul and odorous.

The exhaustion may be due either to the dissolved or fine suspended colloidal sewage matter, or it may be due to the decomposition of the grosser suspended matter which has been deposited upon the bed or shores of the river.

The amount of sewage that can be discharged into a river without nuisance or smell depends therefore not only on the quantity of river water but also upon the quantity of dissolved oxygen contained therein. Therefore, the percentage of saturation of water with dissolved oxygen is used as a measure of the capability of oxydizing the organic matter which may be discharged into that water.

Meaning of "Dissolved Oxygen".

Water can absorb oxygen from the air in the same manner as it dissolves salt or sugar, and just as at any given temperature a certain volume of water can dissolve only a certain quantity of salt and no more, so water at a given temperature can absorb only a certain quantity of oxygen. When the water has absorbed this complete amount of oxygen, it is said to be "100% saturated with dissolved oxygen." When a sample of water contains only one-fourth as much oxygen as it is capable of containing, it is said to be 25% saturated.

Effect of Sewage upon Water.

When sewage is added to a river in reasonable amounts, the natural agencies such as the bacteria, low forms of aquatic plants and animals, and fish are able to consume and convert the vegetable and animal part of the sewage into inoffensive matters. In order to accomplish this change, however, the dissolved oxygen of the water is drawn upon in proportion to the amount and condition of the sewage present.

Percentage Saturation Dissolved Oxygen Required to Prevent Nuisance.

Authorities differ as to the minimum percentage saturation allowable to prevent nuisance and objectionable conditions. The English Royal Commission on Sewage Disposal has reported that 50% is required to maintain major fish life. The Elbe at Hamburg is 40% saturated and is said to be entirely inoffensive.

The authorities at London are satisfied with the condition of the Thames when 30% saturated.

Absence of Sludge Deposits to Prevent Nuisance.

The question of nuisance depends, as mentioned above, also upon the deposited suspended matter or sludge in the bed of the river. This sludge requires a much longer time for decomposition. This fact, together with the continued accummulations is sometimes the only cause of nuisance in a river through the foul gases which it produces.

RELATION BETWEEN FLOW OF THE RIVER AND POPULATION CONTRIBUTING SEWAGE

Meaning of "Second Feet Per 1000 Persons".

In measuring flowing water, the unit used is called a second foot and is a rate of flow when one cubic foot of water flows past the given point each second; 1 sec. ft. for instance, represents a flow of 646,000 gallons per day.

As a measure of the polluting material added to the river it has been found more exact to define the required dilution by the number of persons contributing sewage rather than by the ratio of volume of sewage to volume of river flow, because the percapita flow of sewage varies between wide limits, being as low as 20 gallons per day in Europe and as high as 300 in Philadelphia.

The quantity of waste produced percapita is quite uniform, and therefore the concentrated sewage of 20 gallons per capita contains about 10 times as much polluting material per gallon as the dilute 200 gallon flow sewage.

Chapter I.

History of Sanitation and Sewage Disposal.

Ancient Conditions.

From ancient times, in fact as remote as the time of the Levitical Law, it is found th t they who were responsible for the maintenance of camps, villages, municipalities or cities were charged with the duty of providing means to dispose of the wastes of man and the keeping of places of residence in a fit condition to comfortably support human life.

These arrangements had reached a condition which indicated scientific attention during the time of the Grecian and Roman Empires and existed in various forms among other civilized communities.

During the middle ages however, there seems to have been a marked decadence in the attention paid to sanitary arrangements so that as a natural sequence of this neglect there were periods when plague and pestilence visited communities where there was a considerable concentration of the populace and decimated the inhabitants. Not until the beginning of the Nineteenth Century was there any attempt made to design scientifically and construct a system of conduits to carry off human and industrial wastes under ground. In some countries, the sanitary arrangements, even in populous communities, are still in a primitive condition.

Modern Conditions.

The first modern attempt to construct a system of sewers was made in England and systems after this type have been built and maintained in the Cities of England without much improvement over the early methods until the middle of the 19th century. At that time certain outbreaks of cholera in the large cities required that the matter of sanitation be investigated and this instigated the passage of legislation

It has been found by experience that the condition of a river so far as this feature is concerned can be best studied by determining the rates of river flow to population as "second feet per 1000 persons."

When Crude Sewage is Discharged into Flowing Water.

Chicago.

Much of the crude sewage of the City of Chicago particularly in times of storm formerly flowed into Lake Michigan from which, in an unpurified state, the water supply of Chicago is taken. Instead of constructing water purification works, the Sanitary District of Chicago constructed a canal from Chicago to the Desplaines river, and affluent of the Illinois river. The sewage of Chicago is discharged into this canal; to dilute it a sufficient quantity of water from Lake Michigan is added.

The amount of diluting water was originally fixed at 4 sec. ft. per 1000 persons contributing sewage excluding excessive amounts of trade waste, but later was fixed by law at 3-1/3 sec. ft.

This amount of diluting water was determined largely from experience in America and Europe, where domestic sewage was discharged into rivers. The large amount of industrial waste added to the domestic sewage of Chicago has caused a load upon the purifying power of the diluting water, in excess of the original computations. During the summer of 1911, the water of the canal was examined and it was found that within the sanitary district the water was on an average 50% saturated with dissolved oxygen. The velocity of the water in the canal beyond the city is such as to allow deposits of sludge, which cause in its larger stretches sometimes a complete depletion of dissolved oxygen.

The disposal of the sewage of Chicago by dilution is reported and considered a pronounced success, even in spite of the temporary overloading of the main channel.

New York

The crude sewage of the metropolitan district of New York is discharged into the tidal waters of New York harbor, the Hudson and East rivers. In 1908, the population contributing sewage to these waters was 6,100,000. The waters about New York are tidal and the interrelation between the tidal flow of the Hudson and East rivers through the narrows into Lower New York Bay and through Hell Gate into the Sound, are somewhat complex. The sewage is discharged at the Pier Heads, at the shores and at the surface level of the tidal waters and the opportunities for sludge deposits are at present extensive, both near the shores and in the upper and lower basins.

The effect of this sewage upon the water is that the Hudson river is depleted to 72 per cent saturation with dissolved oxygen; the East river to 65 per cent and the upper Bay to 67 per cent.

At present the entire question of sewage disposal in the metropolitan district is under investigation and consideration, and the actual conditions will be determined within a short time (1 or 2 years).

Boston

The crude sewage of the Metropolitan District of Boston is discharged at three points into the tidal waters of Boston harbor. The outlet at Moon island is provided with larger reservoirs in which the sewage accumulates during flood tide and is discharged during the ebbing tide.

In the immediate vicinity of the outfalls sewage is noticeable but it disappears within comparatively short distances. It does not cause a nuisance nor is the public health of Boston affected injuriously thereby.

2nd class WHEN SCREENED SEWAGE IS DISCHARGED INTO FLOWING WATER.

Washington

A system of intercepting sewer collects the dry weather flow of

sewage of the City of Washington and conducts it to a pumping station where it is passed through a grit chamber and screens, having clear openings of $1\frac{1}{2}$ inch. The sewage is then discharged through submerged outlets in the Potomac river, which is tidal at that point.

The population contributing sewage to the point of disposal is 325,000 and the minimum flow of upland water is about 1400 second feet. This gives a ratio of 4.3 sec.ft. per 1000 persons.

Examination of the river above and below the influence of the screened sewage indicates a very slight reduction in the dissolved oxygen content of the water which is at both places nearly saturated. At the outfall the sewage does not become visible, and the actual point of discharge can seldom be detected, not even sleek (due to oil or grease) being visible.

Hamburg

The conditions at Hamburg have already been described in regard to the water supply. The sewage of about 900,000 persons is collected at a screening station on the bank of the Elbe, first passed through a grit chamber to remove sand, and then through screens having clear openings of 0.4 inch, to remove those solids which would be likely to float upon the surface of the river and present an unsightly appearance. The sewage is finally discharged through three pipes terminating respectively at 230, 330 and 440 feet from shore and in about 30 feet depth of water. It thus becomes thoroughly mixed with the Elbe water, which has an average flow of 2470 sec. ft. This gives a ratio of 2.75 sec. ft. per 1000 persons.

The effect of the sewage upon the water is to lower its dissolved oxygen from 85% the average above the influence of Hamburg's own sewage to 40% below the city, during times of extreme low water.

The sewage does not become visible or odorous which is due to the screening out of the visible floating matter, and its diffusion in the river is affected by the three submerged outfalls. The river is so little affected by the sewage discharge that along the waterfront are a

number of popular cafes and bathing pavilions. (Within a few hundred feet of the screening station is one of the busiest parts of the river.) According to the reports of the Hygienic Institute (Dr. Dunbar, Director) the river is in a satisfactory hygienic condition.

When Screened and Settled Sewage is Discharged into Flowing Water.

Frankfurt a.M.

At Frankfurt a. Main, the sewage of about 345,000 persons is passed through a grit chamber, and screens having clear openings of 0.4 inch, and sedimentation tanks, which together remove 85% of the suspended matter. The sewage is then discharged through a submerged outfall into the current of the river Main.

The average flow of the river is such that there is 17.5 sec. ft. diluting water per 1000 persons. Above the outfall the river is on an average 96% saturated with dissolved oxygen and below 91.5% showing a loss on an average of only 4.5% due to the clarified sewage of over one third of a million people.

London

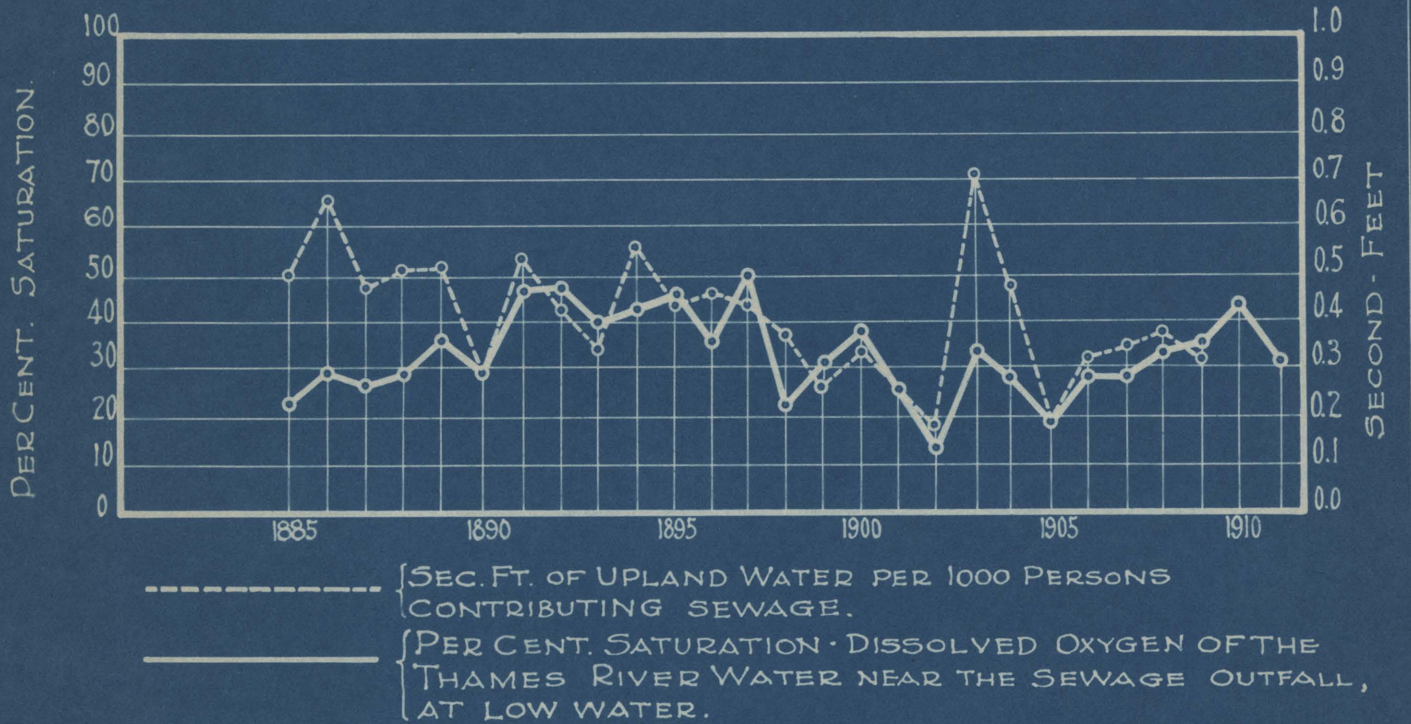
London, the largest City in the world, situated upon a river of which the average flow of upland water is only equal to the extreme dry weather flow of the Delaware river, satisfactorily disposes of its sewage after preliminary treatment, by dilution.

As in olden times in Philadelphia, the early sewers in London were built to carry off only rain and subsurface water; until 1815 it was a penal offense to discharge any sewage into these drains. In 1847 it was however made compulsory to do so and by 1855 the sewage and all surface and ground water were discharged through these drains into the river Thames.

The discharge of the crude sewage from a City having a population at that time of 2,500,000 into the river at numerous outlets, always submerged at high tide, with a probable ratio of less than 1 sec. ft. upland water per 1000 persons, naturally caused a nuisance, notwithstanding

Diagram Showing
Amount of Diluting Water
and the
Effect of the Sewage of the City of
London
upon the Water of the Thames River.

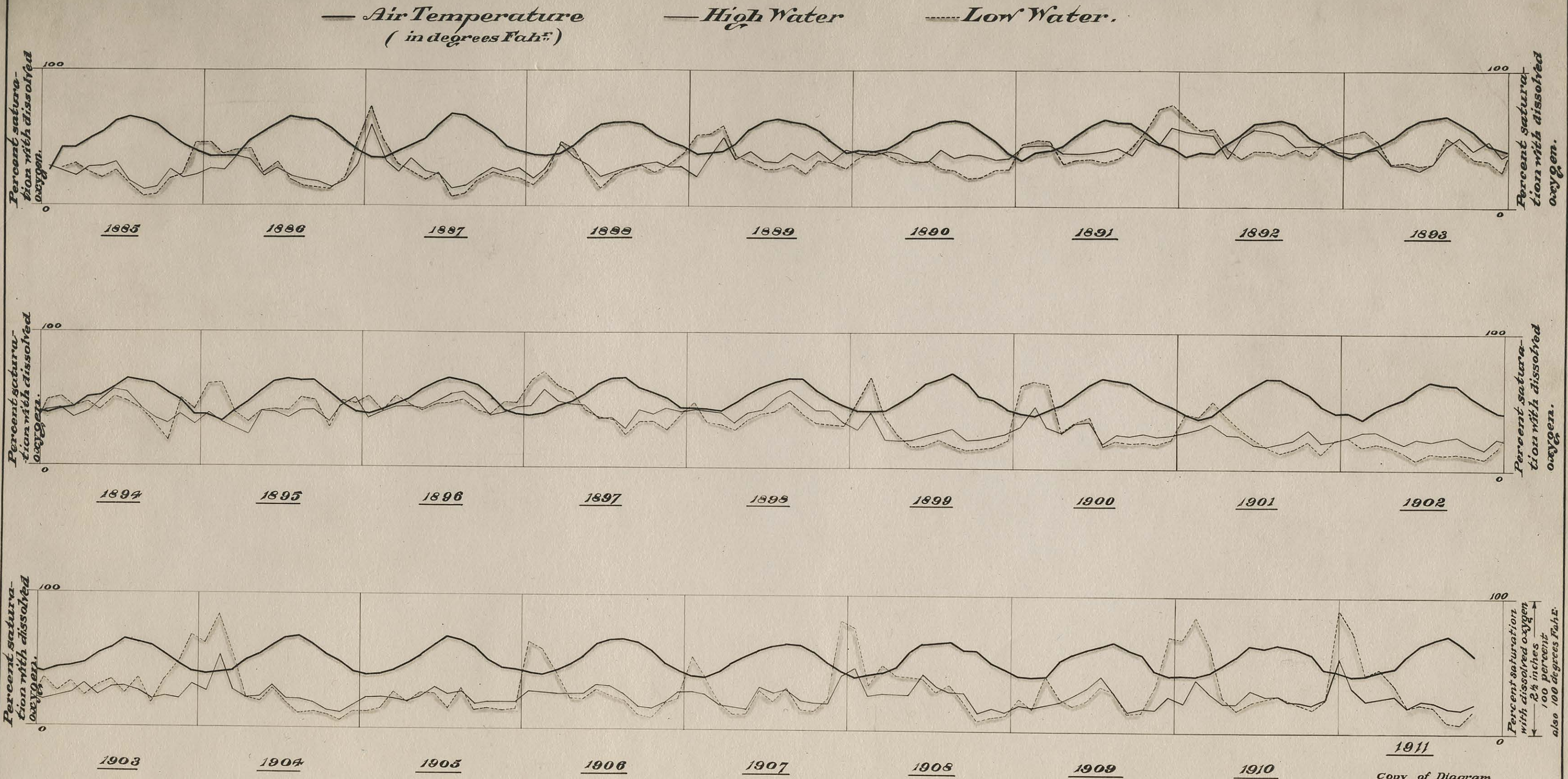
Diagram Plotted from Data Furnished by Mr. Maurice Fitzmaurice, Chief Engineer, London County Council.



Note: From 1885-1889 - Crude Sewage Deodorized in summer.
From 1889-1893 - Crude Sewage Partially Chemically Precipitated and Deodorized in Summer
From 1893-1911 - Chemical Precipitation.
1911 - Average for 10 months.

P.E.M.
1911

Per cent saturation with Dissolved Oxygen of the Thames at Crossness at High and Low Water.



Copy of Diagram
furnished by
Maurice Fitzmaurice
Chief Engineer - London County Council

RH. 1/14/11. added to

the large tidal range of as much as 22 feet in spring tide.

Between 1856 and 1874, the authorities of London constructed intercepting sewers along the banks of the river and conveyed the dry weather flow of sewage to Barking and Crossness, repsectively 11 and 13 miles below the city. At these two stations, reservoirs were constructed to hold 6 hours flow, so as to discharge the stored crude sewage only on the ebbing tide, which tended to carry it away from the City. This affected an improvement in the condition of the river. The population increasing, the load placed upon the river again became too great, and in 1888, the construction of chemical precipitation works was begun and was completed in 1891.

In these works the sewage is freed from a large percentage (about 75%) (~~70% in 1894~~) of its suspended matter, but otherwise the condition of the liquid was worse, due to retention in tanks and to its contact with the deposits in the bottom of the tanks.

This deposited matter or sludge is transported 57 miles down the river, in amount averaging 8,200 tons per day and is finally disposed of by dumping in the estuary of the Thames.

The sewage of London is therefore disposed of in the manner described without creating a nuisance sufficient to cause complaint, partly by dilution with water and partly by removing before dilution about 3/4 of its suspended matter.

In diagram No.   is shown the treatment of the sewage during different periods, the amount of diluting upland water and the effect of the sewage discharge upon the dissolved oxygen in the river water.

The line representing the percentage of saturation from 1885 to 1895 shows by its average rise how the partial treatment of the sewage helped the river to bear its burden.

The diagram shows also how by removing a large part of the suspended matter in the sewage less than 0.5 sec. ft. per 1000 persons prevented nuisance in the river.

Conclusion.

The examples above given, show that a satisfactory disposal of the sewage by dilution is accomplished in a number of large cities without producing a nuisance of injury to the public health.

THE CONDITION OF THE DELAWARE RIVER AT PHILA.

Flow of the Delaware and Schuylkill Rivers.

The amount of water reaching Philadelphia from the watershed of the Delaware river in times of extreme drought has been estimated to be at a rate of 2030 sec. ft. or 1,317 million gallons per day, which is available for sewage dilution.

During months free from freshet or drought it is estimated at an average rate of 4050 sec. ft. or 2,625 million gallons per day, or about double the extreme minimum.

To this upland water should be added the flow available from the Schuylkill river. In times of extreme drought no water passed over the flash boards of the dam at Fairmount, nearly all of it being pumped to filter plants and some flowing through the locks.

D During months free from freshet or drought 1,270 sec. ft. or 825 million gallons per day of water can be depended upon from the Schuylkill river to pass over the dam and to be available for sewage dilution.

The tidal flow in the Delaware river causes a large volume of water to pass the City four times each day. It is estimated that during the flood tide, 1,872,110,729 cubic feet of water flow past the City in 4 hours and 53 minutes or at a rate of 107,000 sec. ft.

Population Contributing Sewage.

It is estimated that in 1910 - 450,000 persons dwelt upon drainage areas in Philadelphia tributary to the Schuylkill, and 1,100,000 persons contributed sewage to the Delaware from Philadelphia. The population of Camden, N. J., was given as 94,538 in the 1910 census.

The Delaware river at Fort Mifflin in 1910 was therefore caring for

the crude sewage of a population of 1,643,546 from Philadelphia and Camden.

In 1950 the population of Philadelphia contributing sewage to the Schuylkill river is estimated to be about one million persons and to the Delaware river about two million persons. Assuming a population in Camden of 180,000, the total population contributing sewage to the Delaware river at Fort Mifflin in 1950 from Philadelphia and Camden would be 3,180,000

Amount of Dissolved Oxygen in The Delaware River.

Examination of April 1910

On April 11th and 14th, the water of the Delaware river was examined in six cross sections.

The figures given below are a weighted average of a large number of samples taken at all points in each cross section.

Location	State of Tide	Per. Saturation Dissolved	Containing Practically
Torresdale	End of Ebb	94.5	Little or no Sewage from Phila.
Bridge St.	Near end of Ebb	80.5	
Tioga St.	Mid tide	61.0	
Christian St.	Mid Tide	60.0	
Point House	Near end of Ebb	59.0	
Fort Mifflin	End of Ebb	53.0	All sewage from Phila. & Camden.

This shows the progressive effect of the addition of the City's sewage upon the river water. The samples analyzed at Torresdale at the end of ebb tide represent "Upland water", but slightly affected by sewage. The samples analyzed at Fort Mifflin represent water which has oscillated in front of the City and the water from the Schuylkill river.

Examination of October 11th, 1910.

Owing to the abandonment of the Testing Station samples for dissolved oxygen were taken only at a single section across the Delaware river and this was selected to be at Arch Street.

On account of a protracted drought of unprecedented intensity and low tides, the condition of the Delaware river at the above date

represented its least ability to oxydize sewage, and samples of the water taken at the cross section between Arch street wharf and Camden at 15 minute intervals for 10 hours and were computed as averages for 3 parts of the section.

The part adjoining Phila.	gave	an	average	saturation	of	34%
The part in mid stream	"	"	"	"	"	40%
The part adjoining Camden	"	"	"	"	"	47.4%

Duting the entire time of this examination no objectionable odors were present.

Examination of Nov. 17th, 1910.

The water was examined at the same cross section and in the same manner as above, the condition of the river being practically normal.

The part adjoining Phila.	gave	an	average	saturation	of	64.1%
The part in mid stream	"	"	"	"	"	74.6%
The part adjoining Camden	"	"	"	"	"	75.6%

Examination of Oct. 20th, 1911.

Under normal conditions again the results were as follows

The part adjoining Phila.	gave	an	average	saturation	of	65.2%
The part in mid stream	"	"	"	"	"	75.1%
The part adjoining Camden	"	"	"	"	"	75.4%

As the condition of the river on October 11th, 1910 was abnormal, a condition which had not existed for many years before that date, and in all probability, would not be repeated for many years to come, it would be rational to consider average conditions during times of drought instead of the extreme condition as above.

Conclusion

From these examinations of the water of the Delaware river, it is evident that the effect of adding at the banks of the river the crude sewage from about 1,600,000 persons (Philadelphia and Camden 1910) is under ordinary conditions, to lower the saturation with dissolved oxygen to 70%, and under most unfavorble condition, to 40%.

COMPARISON OF THE VALUE FOR SEWAGE DISPOSAL
BY DILUTION OF THE UPLAND WATER AND THE
THE TIDAL FLOW IN THE DELAWARE
RIVER

Using the rates of flow given heretofore of the upland water, and of the tidal flow, it will be seen that there is much less (one half to one third) oxygen available for sewage disposal by dilution in the upland water, between a state of saturation and a depletion to a degree which does not cause nuisance to either sight or smell, than that which is available from the much greater volume of the tidal flow, considering in the latter only that portion of the oxygen represented by the difference between the actual depletion observed in the examinations above noted and a depletion to an extent which does not cause nuisance to either sight or smell.

The condition of the river shown by the sanitary surveys described above was brought about by the tidal flow, therefore, to consider only the upland water would be to neglect some of the larger factors of the problem.

COMPARISON OF RESULTS OBTAINED AT OTHER CITIES BY THE DILUTION METHOD OF SEWAGE DISPOSAL

Crude Sewage.

Using the Drainage canal of the Sanitary District of Chicago, as an example of the disposal of crude sewage by dilution, it can be said that 4 second feet of aerated water are required for the disposal of the crude sewage of 1000 persons without nuisance.

Screened Sewage

Using the case of Hamburg, Germany, it may be seen that less than 3 second feet of water were required for the disposal of the sewage of 1000 persons when it is passed through coarse screens, and discharged through submerged outfalls.

Settled Sewage.

The data used to determine the amount of oxygen required for the

disposal of settled sewage are from Frankfort, a.M. Columbus Sewage Disposal Works, and experiments conducted by the Sanitary District of Chicago. By referring to the description of the conditions at Frankfort, a.M., it may be seen that while 17.5 second feet of water were used for the settled sewage of each 1000 persons there was a loss of only 4.5% in the saturation of dissolved oxygen, which indicates an amount of dissolved oxygen absorbed per capita about 35% less than at Hamburg, when the sewage is screened.

In the recent report of the Sewage Disposal Division of Columbus, Ohio, it is stated that the septic tanks at that place remove 60% of the suspended matter in the crude sewage, producing a betterment with regard to stream pollution of 28%.

Laboratory investigations made by the Sanitary District of Chicago showed that by the removal of 63% of the total suspended matter in crude sewage, an improvement of 31% from the nuisance point of view was effected, a substantial agreement with the Columbus result. In regard to these two latter examples, it may be noted that the results given were obtained under conditions in which all re-absorption of oxygen from the air was prevented, whereas, in the other cases cited, natural conditions existed which favored the absorption by the water of oxygen from the air, and it is known that the avidity of water for oxygen increases as it becomes depleted of its dissolved oxygen.

Summary.

The above cited examples of disposal of sewage by dilution are not numerous enough to establish definite factors. An important fact is established that if a body of water is successfully disposing of crude sewage without creating any nuisance, the same condition can be maintained for an increasing population by, first, screening the crude sewage to remove those floating bodies which would be objectionable to

sight, and second, by settling the sewage to reduce the load upon the oxydizing power of the water.

CAPACITY OF THE DELAWARE RIVER TO DISPOSE OF SEWAGE WITH VARIOUS PRELIMINARY TREATMENTS.

Examinations of the Delaware river now disposing of the crude sewage of 1,600,000 persons from Philadelphia and Camden, N. J., show that even in times of unprecedented drought, the river water is not depleted of dissolved oxygen to such a degree as to create nuisance either to sight or smell. In fact, the depletion is not carried to anything near the extent that has existed in the Thames river, London, England, in times when no complaints have arisen. From this, it would appear that the crude sewage from an even greater population than at present, could with safety be discharged into the Delaware river. For purposes of comparison, it may be considered that the population for the year 1918 (which may be taken as the time when the earlier built sections of the works may be placed in operation) would be the limit for the satisfactory disposal of the crude sewage of the entire city.

It may be stated, after applying to the local case, the principles which have been deduced above from other American and German cities, that if the suspended matter is removed from the sewage (by coarse screening and sedimentation) and the sewage discharged into the river in such a way as to diffuse with the current, the Delaware river should be capable of oxydizing the sewage of over 2,250,000 people, a population which is anticipated about the year 1930.

If the conditions at London, England, be considered, it may be seen that this population could be greatly increased without producing objectionable conditions.

If, in the practical developement of the plan for sewage purification, it be found advisable to continue to discharge into the Delaware river the crude sewage of a portion of the city, the river could be

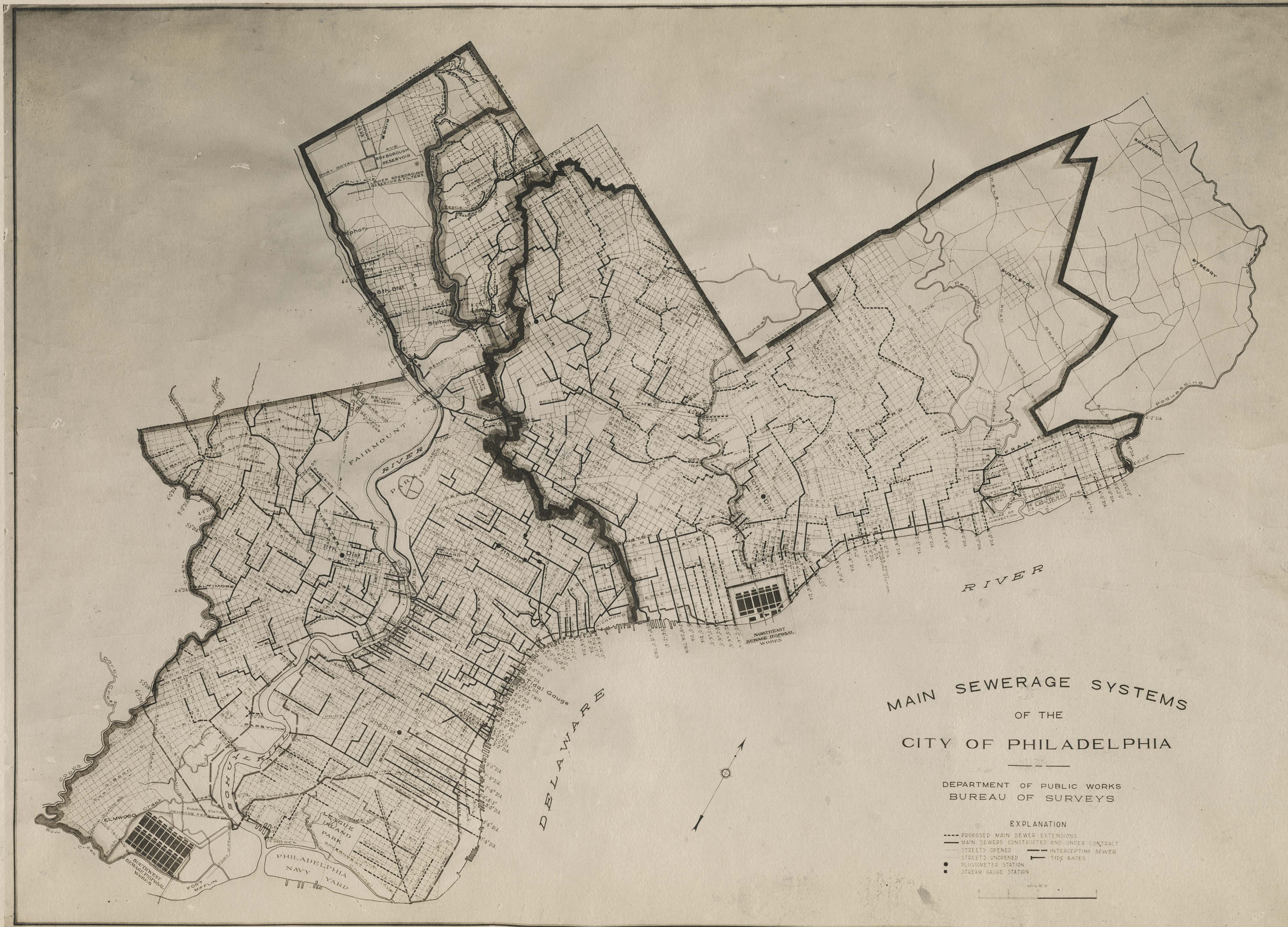
maintained in a correspondingly clean condition, notwithstanding an increase in population, by treating before discharge into the river, the sewage contributed by the increment of population.

CONCLUSIONS.

Disposal of sewage in large rivers within certain limits can be accomplished without creating a nuisance or injury to the public health, provid~~ing~~ed that water supplies taken from such rivers are purified sufficiently to eliminate disease germs, and provided that the quantity of sewage added to the river shall not excessively deplete the river of its dissolved oxygen.

The Delaware river at Philadelphia is capable of assimilating the sewage of a greater population than is now tributary thereto.

The Delaware river at Philadelphia is capable of assimilating the sewage from a considerably increased population by first screening the crude sewage and later by screening and settling it.



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Chapter XI

THE PLAN RECOMMENDED AND SUMMARY OF CONCLUSIONS.

Outline of the Plan Recommended.

The general outline of the plan prepared under the requirements of the State Department of Health and recommended for the completed works may be given as follows:

Two points of disposal with intercepting sewers along both rivers and along tributary streams, carrying the dry weather flow of the existing sewers to these points.

Two main pumping stations to raise the sewage from the collectors to the disposal works.

The construction of disposal works in the units as required, based upon the best practice at the time of construction.

An acceptible method of treatment at the present day consists of sedimentation, percolating filters, final sedimentation and discharge by submerged outlets into the river.

Discussion.

The plan is elastic and can be built in such units as to take care of the increases between 1910 and 1950.

It is to be understood that in providing for the conditions shown to be necessary by the census of 1910, and in applying the 1910 standards to the 1950 conditions, it is to be without prejudice to all necessary modifications of the plan due to improved methods or advances in sanitary science at any time between now and then.

One of the advances which may be anticipated and which would affect the plan largely in its details although not in the main principles, is the possible introduction of water meters upon all service connections to the water system. The introduction of water meters would largely reduce the waste and hence the amount of sewage. It would affect the size of collectors and the size of works, and therefore has a controlling influence on the final design.

The first essentials will consist of the construction of the intercepting sewers necessary to take care of the conditions designated as those of 1910; the construction of the pumping stations for that condition, including the grit chambers and screening devices and the construction of two story sedimentation tanks discharging by submerged outlets into the river.

From the conclusions arrived at under the chapter on "Sewage Disposal by "Dilution", it is desirable that the operation of the system in this condition should extend over a period of years, until it would be found advisable to extend the treatment.

In the study of this subject it is found that the objections to the dilution method of disposal in America appear to have been inspired by an examination of polluted streams used untreated for water supply. These objections may be modified after a more careful study of conditions where the water supply is filtered. A favorable opportunity for such study is furnished ~~formulated~~ by this city, which has constructed and is operating what is said to be the largest, most modern and effective water filtration works in the world.

The limit therefore, of sewage pollution admiss~~a~~ible in a river of the size of the Delaware can best be established in the local case by examining into the efficiency of this water filtration works in so eliminating the effects of sewage pollution as to protect the people from diseases that may be contracted from this source.

Eventually, upon the land which will be acquired for disposal works more refinement in a preliminary treatment before discharging into the river may be added, as necessities require.

There will be found in the appendix dealing with estimates, data in accordance with the sequence herein suggested, which, if examined, in connection herewith, will give a potent reason for these conclusions.

General Description.

The main features of the plan and procedure are as follows:

The land should be acquired for the two disposal works, one in the Northeasterly and the other in the Southwesterly section of the City.

There should then be built the main intercepting sewers which would include the following: for the Northeasterly works, the one along Frankford creek, and along a main avenue leading to the Delaware river from its intersection with the Ashdale street sewer to the pumping station, East of Delaware avenue; along the Delaware river from Linden street to the same; also from Somerset street to the same.

For the Southwesterly works, intercepting sewers should be built along the East and West banks of the Schuylkill river from Fairmount dam to the pumping station near Penrose Ferry; with a branch from the Southward on the

Easterly bank; Cobbs creek extension across the low lands from Cobbs creek, to the same; along the Delaware river from Dyott street to Oregon avenue and from Southwark avenue to Oregon avenue, thence along Oregon, Moyamensing and Penrose avenues from Delaware avenue to and under the Schuylkill river to the pumping station.

There should be built pumping stations with grit chambers and screens at both locations, first, the portions to meet the 1910 conditions, and extended when required to meet the 1950 conditions, with submerged outfalls leading from the works into the channel of the Delaware river.

As the increments of both intercepting sewers and pumping stations are completed, there should be constructed sedimentation and sludge digestion tanks, patterned upon the two story type of tanks, with the accessory sludge drying beds. The cluster of units system should be applied to this feature in order to adjust the number of clusters to the increase in sewage reaching the works.

Necessary effluent collectors from the sedimentation tanks to carry the treated sewage to the submerged outfalls, should then be built in a way to be consistent with the carrying out of the complete plan.

The works should be operated under the conditions of treatment and disposal thus far provided, for an indetermined period, dependent upon observations of the results obtained, or until the depletion of dissolved oxygen, in the Delaware river shall have reached a point regarded as unsatisfactory.

The above conditions having been reached, the plan contemplates the construction of percolating filters to carry the treatment to greater refinement, in which filters, by bacterial action, the effluent from the sedimentation tanks is rendered stable. Final settling basins for removing the mineralized solids washed from the filters should be built as required, the effluent from which, rendered stable and clarified and discharged into the channels of the river, would absorb from it a reduced amount of oxygen.

The clean condition of the Delaware river will be maintained, as the quantity of sewage increases during the passage of years, by the increased refinement of treatment at the works.

In connection with the plan, there will be involved certain repairs, alterations and reconstruction of the existing combined sewers, the construction of tide gates at the present sewer outlets, and other constructions to adapt the present and future systems to each other.

A more complete description of the disposal works, pumping and power stations, the extent of alterations to the existing system, also detailed estimates of the cost of construction and maintenance are given as appendices.

ESTIMATES OF COST.

In order to comply with the requirements of the ordinance authorizing the work of investigation, there have been prepared from the plans and diagrams and from the available information, estimates of the cost of construction and the annual charges (composed of operation, depreciation and interest) of the various sections into which the comprehensive plan has been divided. The sequence of these sections is illustrated on the accompanying diagram for the Northeast works by sections A,B,C,D,E,& F and for the Southwest works by G.H.I. J.& K. A summary of the estimates made up from details given in Appendix D. is given in the following tables:

Various combinations of the sections of the two works are made in the following table to show the cost of construction and annual charges required to accomplish different objects from a hygienic or a prevention of nuisance standpoint:

ESTIMATES OF COST

NORTHEAST SEWAGE DISPOSAL WORKS

Section.	Estimated Cost of Construction including purchase of land and grading.		Annual Charges consisting of operation, depreciation & interest 4%	Drainage area tributary to the works	Method for purification of the sewage before discharge into the Delaware River through submerged outfalls.	For a population of the year.
	Differential	Cumulative				
A	2,824,000	2,824,000	281,000	Frankford Creek	Coarse screens and grit chambers.	1910
B	873,000	3,697,000	337,000	DO.	Coarse screens, grit chambers, sedimentation tanks and sludge drying beds.	1910
C	1,088,000	4,785,000	398,000	Frankford Creek; Delaware River between Torresdale and Northeast Works.	DO.	1910
D	1,170,000	5,955,000	463,000	Frankford Creek; Delaware River between Torresdale and Somerset St.	DO.	1910
E	5,732,000	11,687,000	995,000	DO.	Coarse screens, Grit chambers, Sedimentation tanks, Sludge drying beds and Percolating filters	1925
F	2,375,000	14,062,000	1,236,000	DO.	Coarse screens, Grit chambers, Sedimentation Tanks, Sludge drying beds, Percolating filters and Settling basins.	1950
SOUTHWEST SEWAGE DISPOSAL WORKS						
G	10,153,000	10,153,000	644,000	Schuylkill River and Cobbs Creek.	Coarse screens and Grit chambers.	1910
H	2,338,000	12,491,000	800,000	DO.	Coarse screens, Grit chambers, Sedimentation tanks and Sludge drying beds.	1910
I	4,894,000	17,385,000	1,202,000	DO.	Coarse screens, Grit chambers, Sedimentation tanks, Sludge drying beds and Percolating filters.	1910
J	15,001,000	32,386,000	2,404,000	DO. Delaware River between Dyott St. and Southwark Ave.	DO. Coarse screens, Grit chambers, Sedimentation tanks and Sludge drying beds	1925
K	10,614,000	43,000,000	3,357,000	Schuylkill River; Cobb's Creek; Delaware River between Dyott St. and Southwark Ave.	Coarse screens, Grit chambers, Sedimentation tanks, Sludge drying beds, Percolating filters and final settling basins.	1950

DRAWN BY R.H. 1/23/12
CHECKED BY P.E.M.

Interpretation of Estimates

By examining the foregoing tables, it is apparent that by the expenditure of 6 millions of dollars there may be constructed the necessary works to collect and clarify the sewage entering the Delaware river North of Somerset street as a protection to the intake of the Torresdale Water Filters. This estimate is based upon a popul tion as of the year 1910.

By the expenditure of 10 millions of dollars there may be constructed the necessary works to eliminate the pollution of Cobbs creek and the Schuylkill river, by collecting the sewage now flowing therein and after removing large floating matter and sand, discharging it into the Delaware river below Fort Mifflin. This estimate is based upon a population as of the year 1910.

By the expenditure of 13 millions of dollars, there may be constructed necessary works to eliminate the pollution of Frankford and Cobbs creeks and of the Schuylkill river by collecting the sewage now flowing therein and after removing the large floating matter and sand, discharging it into the Delaware river. This estimate is based upon a population as of the year 1910.

By the expenditure of 16 millions of dollars there may be constructed necessary works to eliminate the pollution of Frankford and Cobbs creeks and of the Schuylkill river by collecting the sewage now flowing therein and removing the suspended matter from it before its discharge into the Delaware river, completing that portion of the plan recommended to be placed in service and to be operated for some years. The works could be operated in this condition during the construction of the works covered by the next section. This estimate is based upon a population as of the year 1910.

By the expenditure of 44 millions of dollars there may be constructed the necessary works to collect the sewage now flowing into Cobbs creek and Schuylkill river and into the Delaware river North of Somerset street, and to purify it on percolating filters and to collect the sewage now flowing into the Delaware river South of Dyott street and to clarify it before its

	Section	For a population as of the year	Estimated Cost of Construction	Annual Charges
To eliminate the pollution of Frankford Creek, and disposal of the sewage by screens and grit chambers	A	1910	2,824,000	281,000
To protect the water supply of Philadelphia by intercepting the sewage flowing into the Delaware River north of Orthodox Street, and dispose of the sewage by clarification	A B C	1910	4,785,000	398,000
To protect the water supply of Philadelphia by intercepting the sewage flowing into the Delaware River north of Somerset Street, and dispose of the sewage by clarification	A B C D	1910	5,955,000	463,000
To eliminate the pollution of Frankford and Cobb's Creeks and of the Schuylkill River and dispose of the sewage by screens and grit chambers.	A G	1910	12,977,000	925,000
To eliminate the pollution of Frankford and Cobb's Creeks and of the Schuylkill river and dispose of the sewage by clarification.	A B G H	1910	16,188,000	1,137,000
To purify on percolating filters the sewage now flowing into Cobb's Creek and Schuylkill river and to clarify the sewage now flowing into Frankford Creek and the Delaware river North of Somerset Street.	A B C D G H I	1910	23,340,000	1,665,000
To purify on percolating filters the sewage now flowing into Frankford and Cobb's Creek, the Schuylkill river and the Delaware river north of Somerset St. and to clarify the sewage now flowing into the Delaware river South of Dyott St	A B C D E G H I J	1925	44,073,000	3,399,000

	Sections	For a population as of	Estimated Cost of Construction	Annual Charges
For the collection, purification and disposal of the sewage of the entire City.	A to F G to H	1950	57,063,000	4,593,000

APPENDIX A.

Description of the

Sewage Disposal Works.

DESCRIPTION OF THE PROPOSED NORTHEAST SEWAGE DISPOSAL WORKS.

Portion of the City, the sewage of which would be Treated at the Northeast Works.

The Northeast works has been designed to care for the sewage from that part of Philadelphia North of Lehigh Avenue (from the Delaware river to Broad Street.) and Northeast of the Germantown and Chestnut Hill Branch of the Pennsylvania Railroad.

Amount of Sewage Used in the Design.

For a Population as of 1950.

Based upon the sewer gaugings, population studies, and capacities of intercepting sewers, the Northeast Works has been designed to purify sewage when flowing to it at a rate of 240 millions gallons per day. This rate of flow is anticipated in .1950, as occurring daily. During times of storm, the rate of flow of the sewage would be increased.

For a Population as of 1910.

Various combinations of the drainage areas tributary to the Northeast works have been made for a population as of 1910 which may be seen in Appendix D and the quantities of sewage in Chapter Vl.

DESCRIPTION OF THE PROPOSED NORTHEAST SEWAGE DISPOSAL WORKS.

Portion of the City, the Sewage of which would be Treated at the Northeast Works.

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Amount of Sewage Used in the Design.

For a Population as of 1950

Based upon the sewer gaugings, population studies, and capacities of intercepting sewers, the Northeast Works has been designed to purify sewage when flowing to it at a rate of 240 millions gallons per day. This rate of flow is anticipated in 1950, as occuring daily. During times of storm, the rate of flow of the sewage would be increased.

For a Population as of 1910

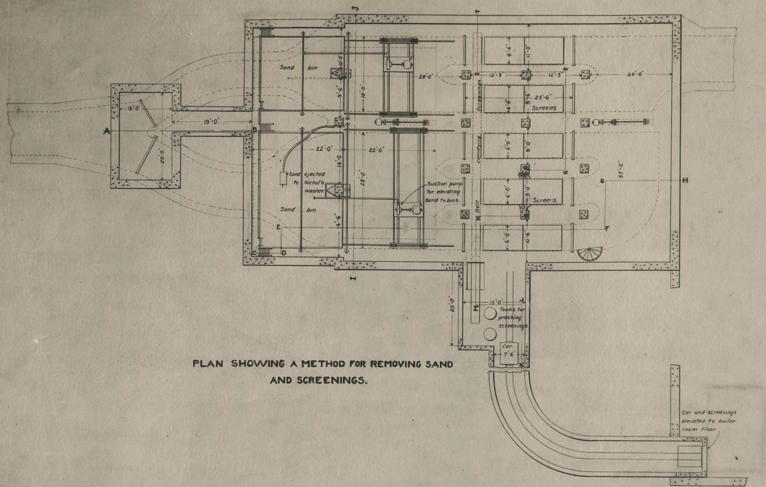
Various combinations of the drainage areas tributary to the Northeast works have been made for a population as of 1910 which may be seen in appendix D and the quantities of sewage in Chapter VI.

Area Required for the Northeast Works.

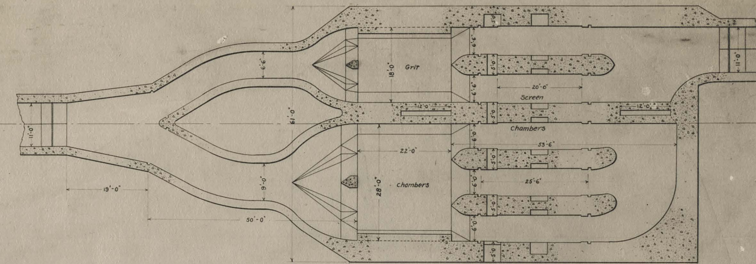
The area required for the complete sewage disposal works would be about 150 acres. As it would be the best policy for the City as a measure of precaution to control a strip of land surrounding the works which could be utilized as a park, an additional area of about 100 acres would be required, making a total of 250 acres.

Grit Chambers.

The three intercepting sewers(along Delaware river, North from Somerset street, and South from Stevenson street, and along Frankford creek) will meet in a junction chamber near the pumping station and their combined flow will be carried by a single conduit to the grit chamber situated under the administrative end of the pumping station, so designed in two parts as to

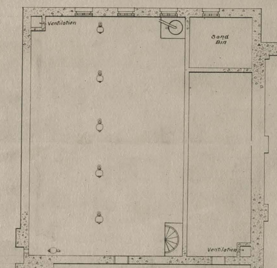


PLAN SHOWING A METHOD FOR REMOVING SAND AND SCREENINGS.

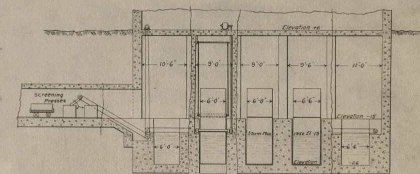


PLAN SHOWING GRIT AND SCREEN CHAMBERS.

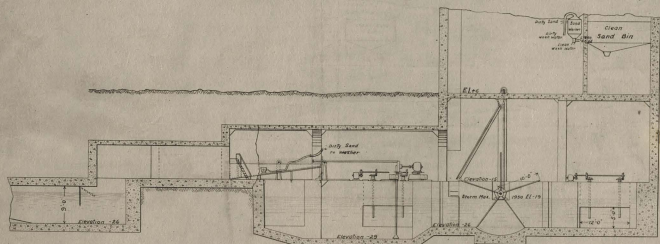
SECTION AT ELEVATION -16



PLAN OF SHOP FLOOR SHOWING SAND WASHER AND MOTORS FOR BELTING AND SCREENS.



SECTION K-L-M-N-O-P-Q-R-S-T



SECTION A-B-C-D-E-F-G-H

SECTION I - J

PLAN
FOR THE
COLLECTION
PURIFICATION & DISPOSAL
OF THE
SEWAGE
OF THE
CITY OF PHILADELPHIA

DISPOSAL WORKS
DIAGRAM OF
GRIT CHAMBERS NORTH EAST WORKS

DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS

SEWAGE DISPOSAL DIVISION

carry respectively 40 and 60 per cent of the total flow. They consist of widened and deepened cross sections as compared with the sewer, so that the velocity of flow will be retarded to between 8 and 15 inches per second. By proper operation, a velocity of 12 inches per second can be maintained. At this velocity, it is expected that the object of the chamber will be accomplished, namely, the deposition in the bottom chiefly of dirty sand.

Removal of Sand.

To accomplish the removal of sand without putting the grit chamber out of service, a motor driven centrifugal pump to draw up the dirty sand from the bottom of the grit chamber will be mounted on a truck capable of motion at right angles to the flow of the sewage; this truck will run on a crane capable of motion parallel to the flow of the sewage, and be able to cover all parts of the chamber. The discharge of the pump will be conducted to an inclined bottom sand bin.

Disposal of the Sand.

The water from the dirty sand having drained back into the inlet end of the grit chamber, the dirty sand will be elevated by an injector to a sand washer located above the main floor of the building. After being washed, the clean sand will be stored in a bin and conveyed by industrial railway, to and utilized in, the sludge drying beds.

Screens.

After the sewage has passed through the grit chamber it will encounter bar screens having about 3/4" clear openings, to remove those floating matters which could injure the pumps or create a nuisance in the river. Each screen will consist of 5 vanes connected to, and rotating about a shaft, or such other device as may be available at the time of construction, proper provision being made for the collection and disposal of the screenings without nuisance.

Division of the Works into Six Units.

The Northeast Works will consist of six unit plants, each practically

complete and independent. Each unit which has been designed to treat sewage at a daily maximum rate of 40 millions gallons, will consist of sedimentation tanks, sludge drying beds, percolating filters, and final settling basin.

Force Mains.

From the pumping station, three force mains will extend to the west or high end of the works, along which there will run a distributing main to supply each unit of the works with its quota of sewage.

Influent Weir House

The proper quantity of sewage is to be delivered to each unit of the works by the distributing main, entering a hopper shaped basin through a gate valve, the sewage being measured as it flows over a weir at the top. Suitable devices for regulating the flow and maintaining the head on the weir will be installed.

Operating Tower.

At about mid length of the distributing main there will be made a connection to what may be called the operating tower. It will contain a reservoir or stand pipe for sewage, a tank for maintaining head on the flushing water system through the works, and an operating floor at the top from which all parts of the works can be see and controlled by electrical connections.

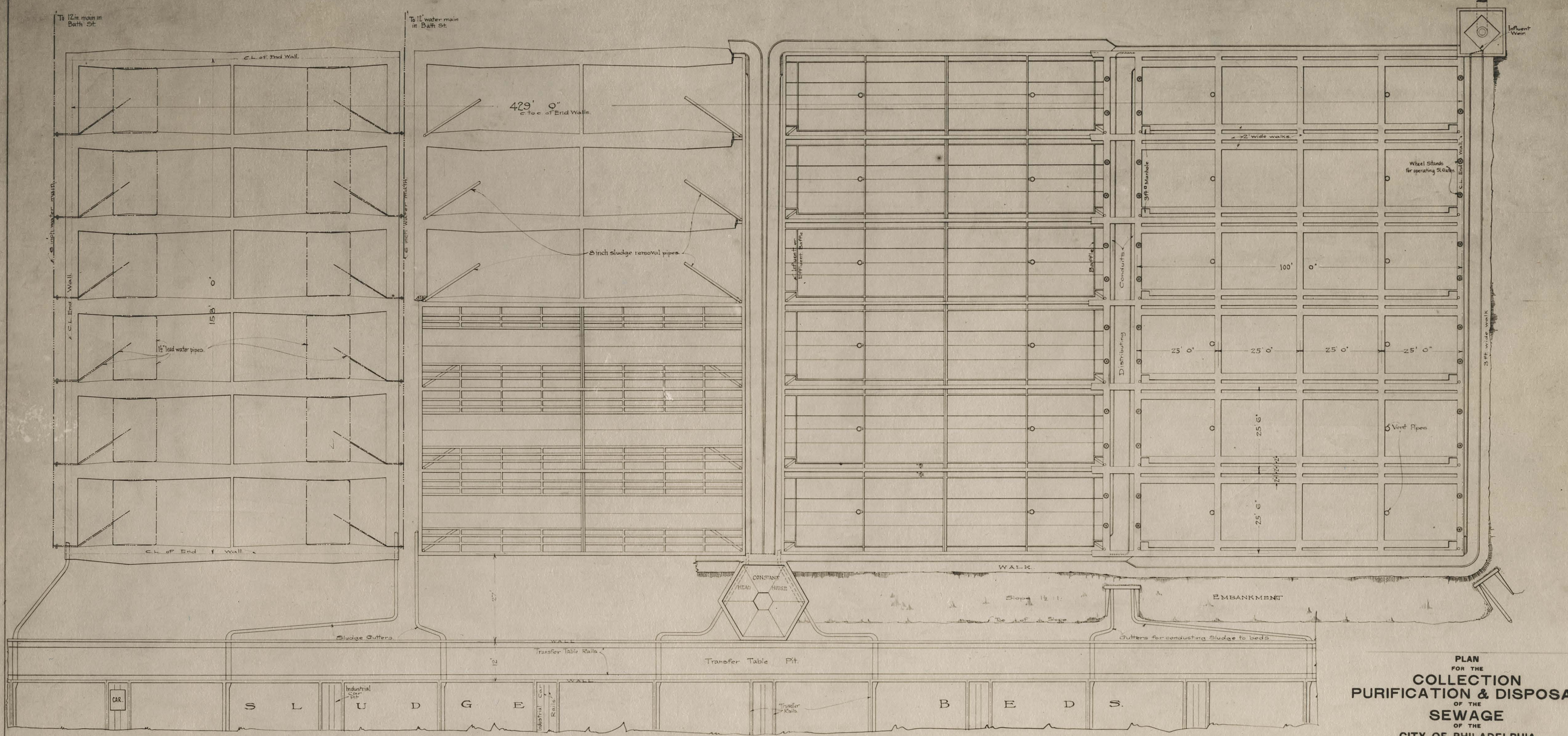
Sedimentation Tanks

Sedimentation.

The suspended matter in sewage that is heavier than water is kept in suspension by the velocity of the current. To remove this suspended matter, therefore, the velocity of flow must be reduced. This is accomplished by passing the sewage slowly and quietly through tanks.

Sludge Digestion.

The suspended matter as it is deposited on the bottom of a tank forms



PLAN
FOR THE
COLLECTION
PURIFICATION & DISPOSAL
OF THE
SEWAGE
OF THE
CITY OF PHILADELPHIA

DISPOSAL WORKS
DIAGRAM OF
A GROUP OF TWO STORY TANKS

DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS

a slimy mass, of which, about 90% is moisture and 10% consists of organic and mineral matters. When the fresh sewage is allowed to remain in contact with this deposit, it becomes fouled thereby and during subsequent treatment causes offense.

It has been found however, by actual practice, that when the sedimentation tank is composed of two compartments, the upper of which is exclusively devoted to sedimentation and the lower to sludge digestion that the condition of both the settled sewage and the sludge as withdrawn have different characteristics from those obtained in the case of the usual form of one story tanks. Satisfactory results with sludge digestion have been obtained in Germany with a tank of this form, and from published data showing similarity between sewage composition there and here, and also from the satisfactory results obtained at the Philadelphia Sewage Experiment Station designs provide for the use of two story tanks.

Description of Tanks.

Distributing and Collecting Conduit.

Each unit of the works is provided with two groups of twelve tanks; each group is served by an influent weir house.

The tanks are surrounded by open conduits so designed that they may act either as influent or effluent channels, thus the direction of flow in the tanks can be reversed or two tanks run in series.

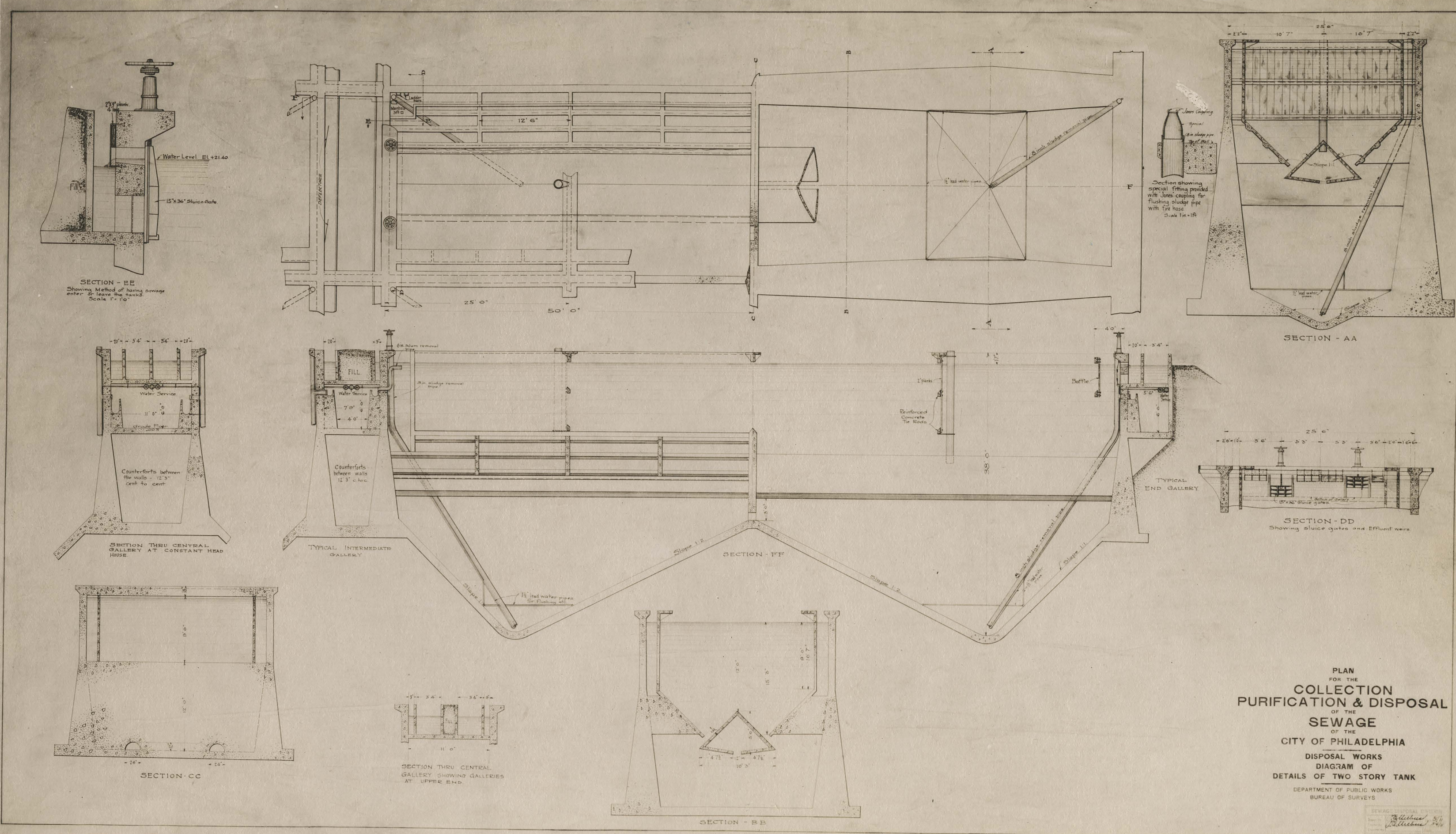
Sedimentation Portion

The sewage will enter the tank through two sluice gates, flow under scum boards to restrain floating matter at the inlet end, over a baffle and out of the tank over a moveable weir.

As the sewage flows through the tank the suspended matter will settle down upon the smooth inclined false bottom along which it will slip through openings into the lower part devoted to sludge digestion.

Sludge Digestion Portion.

The concrete bottom of the tank is formed like a hopper, and an iron



PLAN
FOR THE
COLLECTION
PURIFICATION & DISPOSAL
OF THE
SEWAGE
OF THE
CITY OF PHILADELPHIA

DISPOSAL WORKS
DIAGRAM OF
DETAILS OF TWO STORY TANK

DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS

pipe will extend from the lowest point of this hopper bottom to a gallery to be built between each cluster of six tanks. The outlet or free end of this pipe will be lower than the surface of the liquid in the tank, and upon opening a shear valve controlling the discharge, the sludge from the deepest part of the hopper will be impelled into a gutter running through the gallery and thence flow to the sludge drying beds.

Sludge Drying Beds.

Description.

The sludge drying beds will consist of underdrained areas separated by concrete walls into individual beds. The material upon which the wet sludge will be run will consist of coarse gravel or broken stone covered with a layer of sand.

The underdrains will lead to a sewer which connects with the main interceptor from Frankford creek and so the drain water from the sludge bed will mingle with the crude sewage at the pumping station and passthrough the works.

The sludge will dry to such an extent in from 5 to 7 days, as to be fit to remove.

Removing Dried Sludge.

For removing the dried sludge from the surface of the sand, a machine has been designed to eliminate the usually unsatisfactory hand labor. It will consist of a truss carried by wheels running on rails along the concrete walls separating the beds. This truss carries a digger working like a bucket conveyor. By this the dry sludge will be removed from the bed and discharged upon a belt conveyor running along the top of the truss and discharging at the end into industrial cars, which will convey the sludge to places of deposit. Electricity will operate the machine and cars will be furnished with power from trolley wires supported on catenary suspension cables.

Disposal of Dried Sludge.

The experience in Germany in operating sedimentation and sludge digestion

tanks without offense from either wet or dry sludge has been confirmed in America on experimental scale by the Bureau of Surveys.

The dried sludge being inodorous and like garden soil, can be used to fill in the low lands along the shore of the river. It is estimated that the low part of the area of 250 acres is capable of being filled to street grade with a four feet deep layer of gravel to exclude tide water and with the output of sludge from the Northeast Works until 1950.

Percolating Filters.

Object.

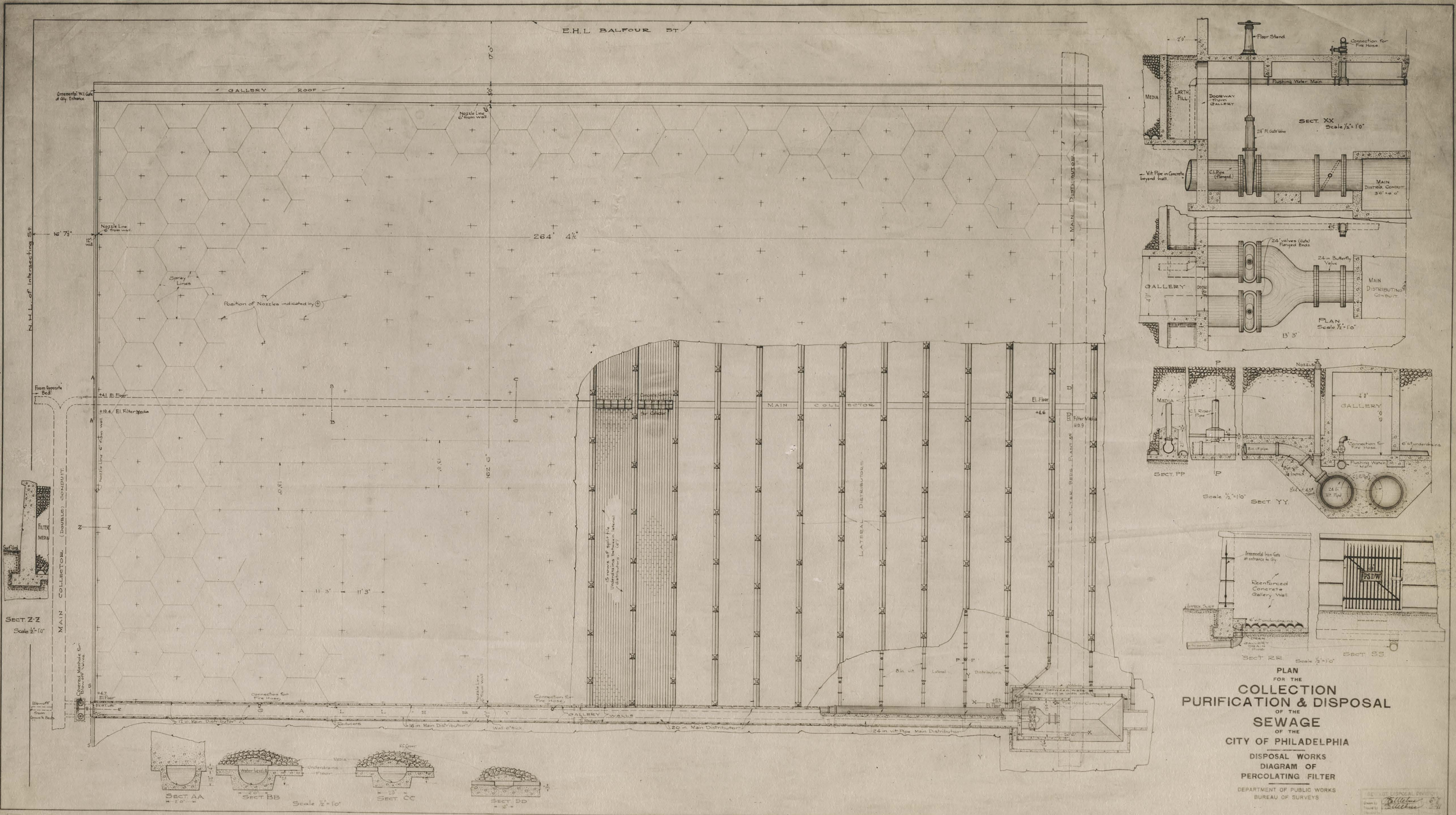
Sewage as received at a disposal works consists of the water supply contaminated with domestic and industrial wastes. These wastes are part in suspension and part in solution. The suspended matter can be largely removed by the sedimentation tanks. Of the soluble matter a part is organic and putrescible. It has been found that during the process of sprinkling sewage (freed from a part of its suspended matter) over a bed of stones, a jelly like substance forms upon the surface of the stones and the sewage in passing over these films is acted upon by the bacteria so that when collected from the drains at the bottom of the bed the organic, putrescible matterhas been to a considerable extent converted into a stable or non-putrescent condition.

Constant Head House.

The collecting conduits of the sedimentation tanks all lead to a hexagonal reservoir which is the inlet or upper end of the conduit which will supply the percolating filters withthe sewage. The elevation of the liquid in this tank will be kept at a nearly constant elevation by varying the number of acres of percolating filters in service as the flow of sewage varies.

Influent Conduit.

Extending from the constant head house, under the sludge drying bed,



E.H.L. BALFOUR ST
GALLERY ROOF
Ornamental W.I. Gate & Gly. Entrance
Nozzle Line 6' from wall
264' 4½"
N.H.L. of Intersecting St
16' 7½"
Spray Lines
Position of Nozzles indicated by (+)
From Opposite Bed
MAIN COLLECTOR
El. Floor
El. Filter Media
MAIN COLLECTOR (DOUBLE) CONDUIT
162' 0"
13' 0"
11' 3"
11' 3"
15 rows of split tile Underdrains between lateral distributors
LATERAL DISTRIBUTORS
MAIN DISTRIBUTOR
C.L. FILTER BEDS PLAN
Covered Manhole & Blow off Valve
Blowoff from Opposite Beds
Connection for Fire Hose
GALLERY
GALLERY WALLS
Main Distributor
Reducers
18 in. Main Distributor
Wall 6" thick
20 in. Main Distributor
24 in. vit. Pipe Main Distributor
8 in. vit.
Lateral
Distributors
SECT. Z-Z
Scale ½" = 1'0"
FILTER MEDIA
SECT. AA
SECT. BB
SECT. CC
SECT. DD
Scale ½" = 1'0"
Media
Underdrains
Floor
Water Level
Floor Stand
Connection for Fire Hose
Flushing Water Main
MEDIA
EARTH FILL
DOORWAY from GALLERY
SECT. XX
Scale ½" = 1'0"
24" Pl. Gate Valve
Vit. Pipe in Concrete beyond Wall
C.I. Pipe (flanged)
MAIN DISTRIB. CONDUIT
24" valves (Gate) Flanged Ends
24 in. Butterfly Valve
GALLERY
MAIN DISTRIBUTING CONDUIT
PLAN
Scale ½" = 1'0"
13' 5"
NOZZLE
MEDIA
C.I. Riser Pipe
GALLERY
Connection for Fire Hose
Flushing Water Main
6" Underdrains
SECT. PP
Scale ½" = 1'0"
SECT. YY
Ornamental Iron Gate at entrance to Gly.
Reenforced Concrete Gallery Wall
PSDW
SECT. RR
Scale ½" = 1'0"
SECT. SS
PLAN
FOR THE
COLLECTION
PURIFICATION & DISPOSAL
OF THE
SEWAGE
OF THE
CITY OF PHILADELPHIA
DISPOSAL WORKS
DIAGRAM OF
PERCOLATING FILTER
DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS

to and under the percolating filters there will be a reinforced concrete conduit to deliver the influent to the percolating filter beds. This can also serve as a bypass to the river prior to the construction of the percolating filters.

Regulating House.

In the center of each four acres of percolating filters there will be a regulating house to control the distribution of the influent upon the filters. On each side of the influent conduit under the regulating house there will be a connection made to a butterfly valve beyond which the pipe divides into the main distributors each serving one acre of filter bed. As the sewage in the influent conduit is under a constant hydraulic head, due to the elevation of the surface of the sewage in the constant head house, the alternate opening and closing of the butterfly valve controlled by an electrical device will produce an undulating head upon the distributing system of the filters.

Distributing System.

From the main distributor pipe (laid under the floor of the gallery, to be described) connections will be made to the lateral distributors laid along the floor of the filters; vertical riser pipes will extend from the lateral distributors to the surface of the filter beds and to the tops will be fastened spraying nozzles to distribute a film of sewage over the filter surface.

The opening and closing of the butterfly valve will cause these films to cover the entire bed.

Medium.

The medium of the filter consists of a layer of broken stone about the size of ballast used on railroads and extending from the floor of the filter to just below the spraying nozzles. The sewage after it has been distributed upon the medium will trickle or percolate down over the

surface of the stones until it reaches the smooth concrete floor of the filter.

Underdrains.

To maintain a clean floor for the filter there will be placed upon the surface of the concrete floor half round terra cotta pipes with the curved surface uppermost upon which the stones composing the filter medium will rest. The sewage after having percolated through the medium will flow along the sloping floor to a main effluent collector extending along the middle of the bed and leading to the effluent conduit.

Galleries.

Extending from street to street, laid out through the works for convenience of construction and transportation, between sections of percolating filter bed there will be a concrete gallery, containing water service for flushing the filter floor through the openings in the gallery where the underdrains extend through the walls. The attendants will be able to reach the regulating houses either on top of or through these galleries.

Settling Basins

Object.

The function of the percolating filter is not to clarify sewage but to render it nonputrescent. At times the filters do however store up the suspended matter contained in the influent and later discharge it with the effluent. At such times the effluent appears to be much worse than the influent due to large flaky pieces of the dried films washed from the surface of the stone. To remove these solids, which settle much easier than the solids suspended in crude sewage, the effluent from the percolating filters will be passed through settling basins.

Distribution of Influent.

As the settling basins are near the river where excavation would be

very costly they will be built as clusters of shallow basins, having a distributing channel along the inlet end.

The treated sewage will enter each settling basin through two sluice gates and flow over a weir extending the entire width of the tank.

Each tank will consist of a rectangular basin having a depressed bottom at the inlet and toward which the floor slopes.

Effluent Channel.

The effluent will be drawn off over a weir extending the entire width of the tank but provided with piers slotted for stop planks, so that any tank can be cut out of service for cleaning.

After flowing over the weir the effluent is collected into a conduit running along the entire length of the cluster of tanks and leading to the river outfalls.

Removal and Disposal of Sludge.

The sludge which forms on the bottom of these settling basins is composed of more easily settled material than that in crude sewage and therefore instead of removing it to sludge drying beds, it has been planned to empty the sludge in small quantities and at frequent intervals into the intercepting sewers lying in front of the settling basins. The sludge will mingle with the fresh sewage and be pumped to the sedimentation tanks where it will settle out and be subjected to the before described digestion in the bottom of the tank.

Outfall Conduits.

The channel of the Delaware river at the site of the Northeast Works is slightly beyond the pier head line and the water is rather shallow near the dike. In order to effect diffusion of the effluent of the works with the river water, that it may not become visible nor affect the shores, submerged outlets have been designed to discharge at the pier head line in about 25 feet of water.

PROPOSED DESCRIPTION OF THE SOUTHWEST SEWAGE DISPOSAL WORKS.

Portion of the City, the Sewage of which would be treated at the Southwest Works.

The Southwest works has been designed to care for the sewage from that part of Philadelphia South of Lehigh Avenue (from Delaware river to Broad Street) and Southwest of the Germantown and Chestnut Hill Branch of the Pennsylvania Railroad.

Amount of Sewage used in the Design.

In 1950

The complete works have been designed to purify sewage when flowing to it at a rate of 650 millions gallons per day. This rate of flow is anticipated as occuring daily in 1950. During time of storms the rate of flow of the sewage would be increased.

In 1910.

The amount of sewage estimated to reach the works in 1910 is 135 millions gallons per day, that from the Delaware river drainage area, South of Dyott street, owing to the length of time required for the construction of collectors, not being included.

Area Required for the Southwest Works.

The city already ownes land upon which it is proposed to locate the Penrose Ferry Pumping Station. Additional land is required for the site of the Southwest Disposal Works amounting to about 625 acres.

Features Similar to the Northeast Works.

The general features of this plant will be similar to those of the Northeast Works.

Screens

As an alternate to the revolving vane screens proposed for the Northeast Works it is planned to use vertical screens in duplicate capable

of being hoisted out of the sewage for cleaning.

Grit Chambers.

The intercepting sewers will deliver sewage at the Southwest or Penrose Ferry Station at three levels and hence to economize pumping the grit chambers are in three parts at different elevations.

Division of the Works into two parts.

The magnitude of the Sothwest Works, and the collection of the sewage from two widely separated districts required the designing of both the pumping station and the works, so that they could be built and operated in two parts, one treating the sewage from the Schuylkill, the other from the Delaware river basin.

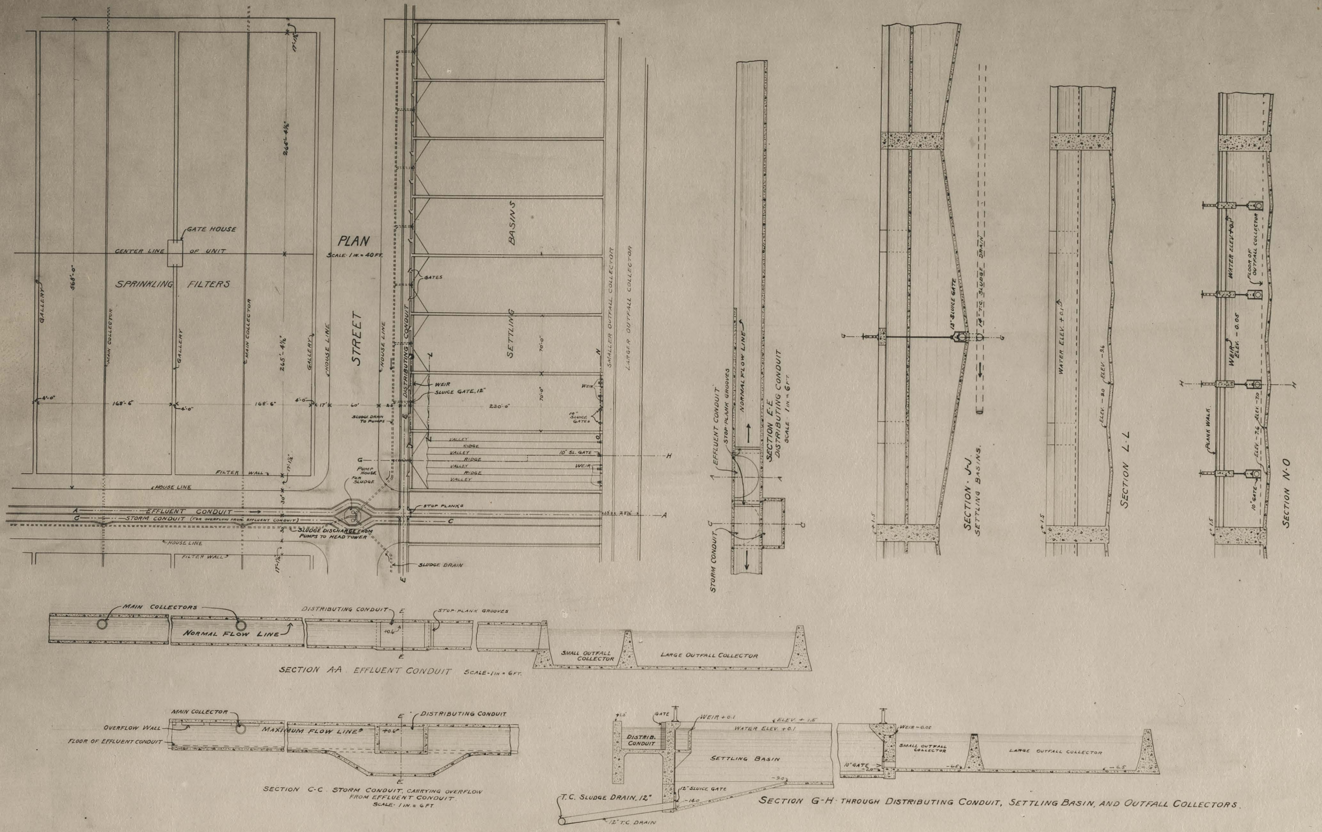
Each part of the disposal works consists of nine units, any number of which could be built as occasion demanded.

Force Mains.

Four force mains will extend from the Penrose Ferry Pumping Station to the sewage disposal works, each one terminating in an operating tower. From these operating towers the sewage will be delivered to the Sedimentation tanks by distributing mains.

Effluent Collectors.

As in the Northeast Works the sewage will pass through two story sedimentation tanks, having adjoining them sludge drying beds; and through percolating filters. The effluent collectors however, are different. In the middle of each street between the percolating filters will extend a twin conduit, one half designed so as to carry the effluent from its adjoining filters under normal conditions, but of sufficient capacity to act as a bypass prior to the construction of the percolating filters, the other half being used in times if storm to carry the effluent and rain water.



PLAN
FOR THE
COLLECTION
PURIFICATION & DISPOSAL
OF THE
SEWAGE
OF THE
CITY OF PHILADELPHIA

DISPOSAL WORKS
DIAGRAM OF
FINAL SETTLING BASINS

DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS

Removal of Sludge.

As there will be no intercepting sewer in front of the settling basins, as in the Northeast works, the sludge will be blown off to sludge pumping stations, from the hopper inlet end of the settling basins. The flat floors will be flushed with river water at high tide by opening the sluice gates at the outlet end.

Sludge Pumping Station.

In the complete works there will be four sludge pumping stations. The sludge will be discharged through force mains to the lower part of the sewage tank in the four operating towers, where it will mingle with sewage and be evenly distributed among the sedimentation tanks and subjected to digestion in the lower part thereof.

Outfall Collector.

A main outfall collector will extend along the entire lower length of the works into which the effluent of the settling basins will be discharged over their outlet weirs. The effluent collectors will also be connected as a bypass directly to the outfall collector. This outfall collector will consist of an open channel designed so as to be built in two parts to accommodate the growth of the works. It will extend to the bank of the Delaware river

Along the East side of the works will also be constructed an open channel to connect the first force main to be built to the outfall collector. This will serve as a bypass during the first stage of construction.

Outfall Gate House.

Between the outfall collector and the submerged outfall, there will be built a gate house so that by closing off one of the outfalls a high velocity can be obtained and the submerged outfalls thoroughly cleansed of any deposits.

Submerged Outfalls.

These will consist of three conduits extending under the bed of the river to the channel where proper appliances will cause rapid diffusion of the effluent with the tidal current of the river.

APPENDIX B.

Description of the

PUMPING AND POWER STATIONS

DESCRIPTION OF PUMPING & POWER STATIONS.

The power plants of the comprehensive plan must be sufficient for all needs of pumping, telpherage, lighting, operating devices, machine shops and all accessories.

The pumping station must first of all be reliable, it must be ready to run at all times and must be able to handle all the sewage coming to it. Its total capacity must be so divided that the varying flow can be taken care of in the most economical manner, both as to the effeciency of the pumping units and as to the amount of attendance required, also divided so as to allow of partial installation. The equipment selected should answer the above requirements, and in addition, it should require the lowest total operating cost, composed of fixed charges, maintenance and direct operating cost.

Comparison of Types of Pumps.

The two main divisions of pumping machinery suitable for this work are reciprocating pumps of the water works type and centirfugal pumps, either engine or motor driven. The advantages of the first class are: high coal economy, reliability and the proved test of long continued service; the disadvantages are high first cost, large size for moderate capacities, high labor charges and the fact that they are essentially high head pumps. In favor of the centrifugal pumps are the following characteristics: low first cost, moderate size, for large capacities, less skillful attendance required, simplicity of construction, large water passages and the fact that they are particularly well adapted to the handling of large overloads against moderate heads. The disadvantages are the lower coal economy, and the possibility of erosion due to the presence of grit.

Based on the 1910 conditions for the Northeast Pumping station and on the present state of the art, a study was made of the following combinations to determine the most suitable type of pumping equipment;

reciprocating pumps - triple expansion engines - water works type.

Centrifugal Pumps.

(a) Geared turbine drive

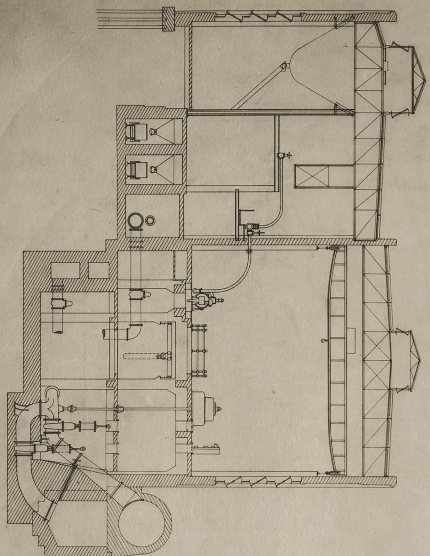
(b) vertical shaft engine drive

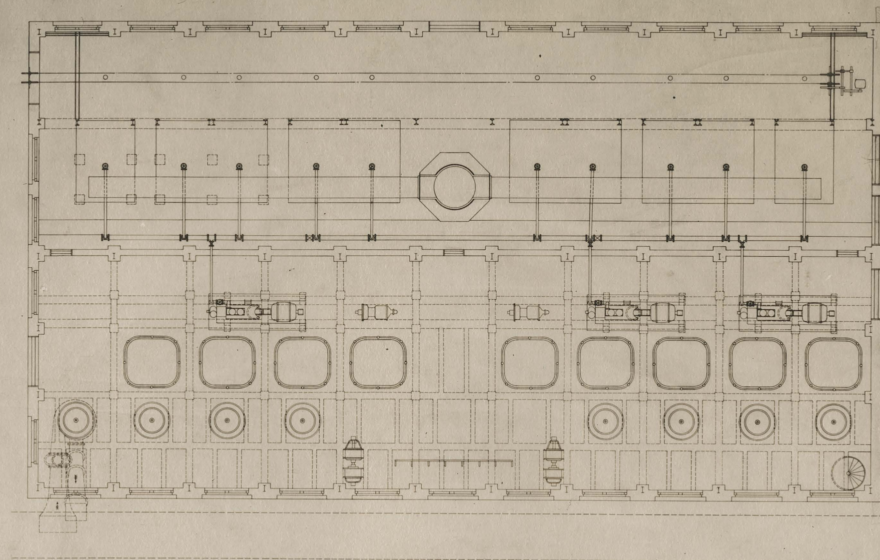
(c) Motor drive - turbo-generators.

This investigation showd a decided saving, both in first cost and in total operating expenses in favor of the centrifugal pumps. A further study led to the conclusion that the geared turbine drive and the motor drive, with turbo-generators were best suited to the given condition. Alternate pumping station designs based on the above conclusions, were prepared for this station. As the conditions to be met at the Southwest Station are quite similar, one design was considered sufficient for that plant.

NORTHEAST PUMPING STATION.

The proposed station for the Northeast section is located tentatively on the East side of Delaware avenue, in the vicinity of the Pennsylvania Railroad bridge across the Delaware river. The intercepting sewers brign sewage from North, West and South to the pumping station. After passing through the grit and screen chambers, the sewage will flow into a suction conduit running along the west wall of the station. The main building has been planned so as to have the greater dimension parallel to Delaware avenue. An extension on the south provides for shops, screen chamber machinery, and general administrative needs. The western half of the main building is to be devoted to the pumping machinery. The eastern half will contain the necessary boilers, an incinerator for disposing of the sewage screenings, coal bin, etc. On the northern end of the boiler house will be a coal and ash tower.





PLAN
FOR THE
COLLECTION
PURIFICATION & DISPOSAL
OF THE
SEWAGE
OF THE
CITY OF PHILADELPHIA

NORTH EAST PUMPING STATION
MOTOR DRIVEN
CENTRIFUGAL PUMPS

DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS

SEWAGE DISPOSAL DIVISION		
Drawn by	J. B. Schmidt	Date 6-20-11
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Checked by		Date

Type of Architecture.

The architecture of the building will be Renaissance in character, with very large windows to insure good lighting. The exterior design of the boiler and engine rooms calls for a heavy base, shows groups of windows, with larger windows above, the whole surmounted by a classic cornice and a parapet. This treatment gives the expression of open and spacious interior rooms. In the adminstration building, it was the aim to secure the same effect to make a harmonious design.

Interior Finish.

The interior finish of the pump room is left open, but it will be treated in a manner, pleasing and harmonious with the main design, adaptable to the uses of the building.

The treatment of the boiler room will be accordance with the utilitarian requirements.

Boiler Room Equipment.

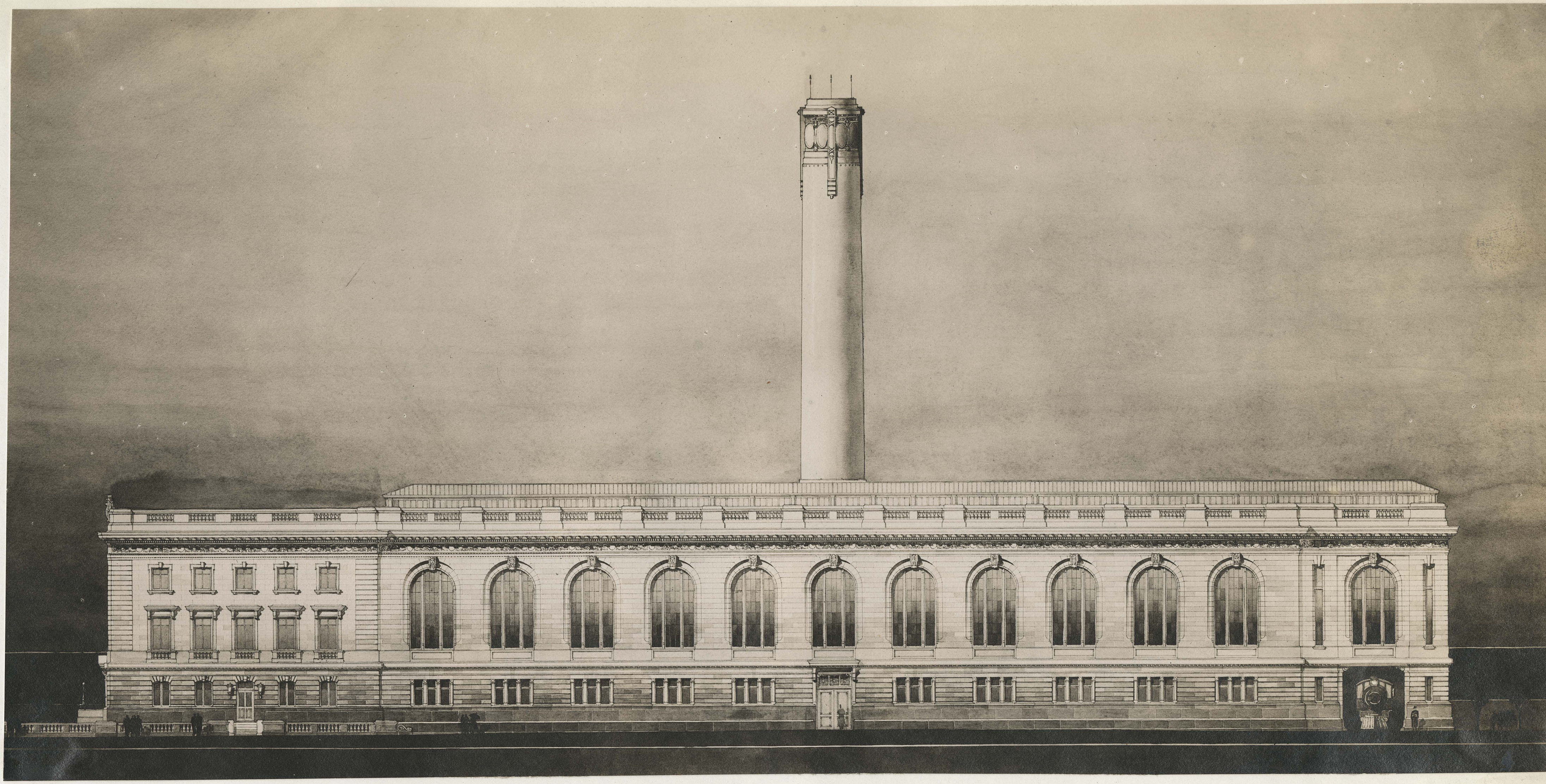
The boiler room equipment will be divided into 500 H. P. units, arranged singly and in batteries. A special design of setting and grate in one of the boilers will take care of the dispoal of the [redacted] screenings coming from the screen chambers. The boilers are to be water tube boilers, fitted with superheaters and with mechanical stokers.

Running the length of the boiler room, there will be provided an overhead coal bin supplied by a conveyor. The station will be supplied with a modern ash handling equipment.

Pump Room Equipment.

Motor Drive Plan

Along the east wall on the main or operating floor of the pump



SIDE ELEVATION

PUMPING STATION
NORTH EAST SEWAGE DISPOSAL PLANT

SCALE 1/8" = 1'-0"

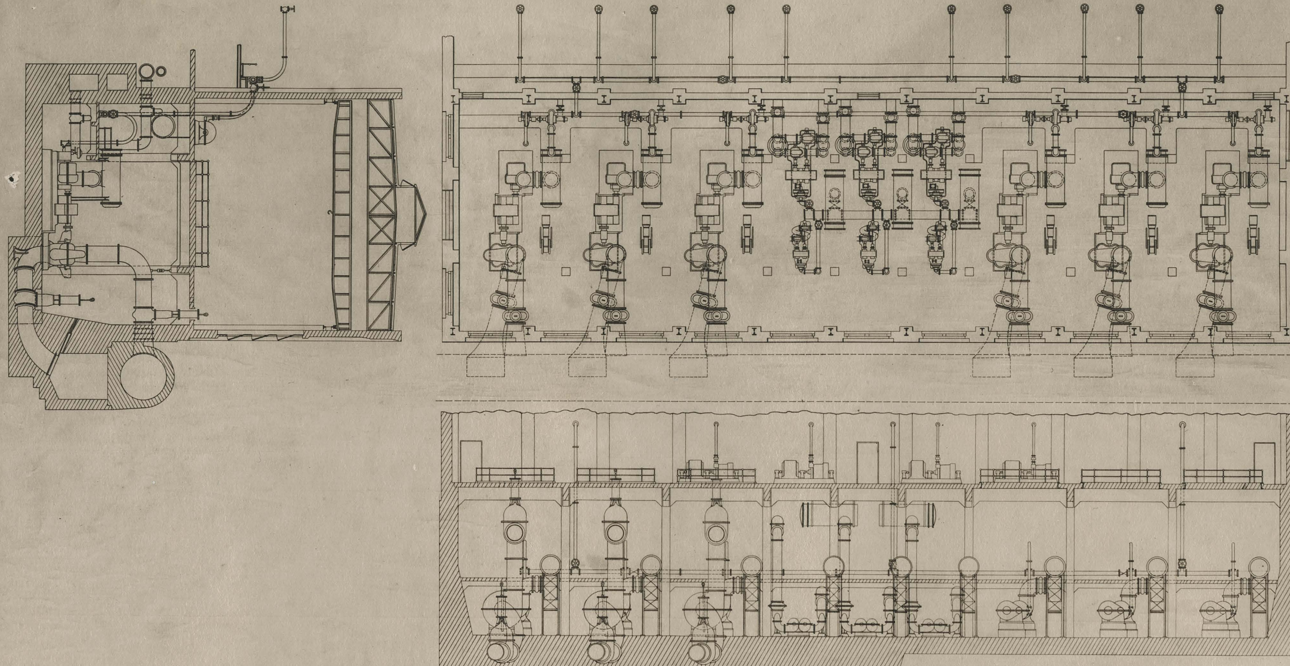
room will be placed the 1000 K. W. steam turbine driven alternstors which will generate the power for driving the pumping machinery. The switch and control boards will be on the North side of the room, facing the rows of pump motors and the generators. The pumping units will be vertical shaft centrifugals, placed in the basement below the level of the sewage in the suction mains. The driving motors will be on the main floor, directly connected to the extensions of the pump shafts. To meet the maximum 1950 demands upon this station, there will be required 8 units, each having a capacity of 40 millions gallons per day. Hydraulically op rated gate valves on both suction and discharge pipes will provide for either a temporary or a permanent shutting down of a unit. The discharge from each of the pumps will lead into a large steel and concrete leader, from each end of which force mains will conduct the sewage to the disposal works, or through a bypass to the submerged outfall in the river.

A basement mezzanine floor will provide room for the usual auxilliaries such as air pumps, circulating pumps, condensers, etc., and for several turbine driven pumping units for supplying wash water to the disposal works.

The vertical electric travelling crane will serve the main floor and through light wells will serve part of the basement area. A smaller crane in the basement will provide for the further handling of heavy pieces during installation and repairs.

(b) Geared Turbine Plan.

In this design, with the exception of the smaller turbine driven generators for supplying light and miscellaneous power and their switchboards, the main floor will become practically a visitors' gallery. The pumping units in this case will be horizontal shaft units, each driven through reduction gearing by a steam turbine mounted on the same foundation. For the design, the ultimate equipment would consist of six 60



PLAN
FOR THE
COLLECTION
PURIFICATION & DISPOSAL
OF THE
SEWAGE
OF THE
CITY OF PHILADELPHIA

NORTH EAST PUMPING STATION
GEARED TURBINE DRIVEN
CENTRIFUGAL PUMPS

DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS

SEWAGE DISPOSAL DIVISION
Drawn by J. B. Schmidt Date 6-12-11
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Checked by Date

millions gallons per day units. A second steam leader, running along the boiler side of the basement room will supply the main units and the auxilliaries. The feed pumps, feed heaters and wash water pumps will occupy the middle third of the room. The general features of the works will be the same as for the motor driven design.

Administration Building.

The main entrance to the pumping station will be through the administration building. The first floor will provide for store rooms, a machine shop, and a machinery room over the screen and grit chambers. On one end of the second floor, reached by a separate stairway, will be toilet and wash rooms, locker rooms and a lunch room for the operating force. On the other end of this floor willbe the offices of the Chief operator and his assistants.

A third floor necessary to make this building conform to the main structure, will be available for use as draughting rooms, coal analysis laboratory, etc.

PENROSE FERRY PUMPING STATION

The location proposed for this station is in the 40th ward. The pump building, will face and be parallel to Fort Mifflin Road, near Penrose Ferry Road upon property owned by the City. The intercepting sewers coming South on both sides of the Schuylkill river, coming East from Cobbs creek and coming West from the Delaware river district will converge at this poing and the sewage after passing through screens and grit chambers will discharge into three suction conduits at different levels.

The two boiler houses are placed near the ends of the pump building, running at right angles to it. The general structural features of the buildings are the same as for the Northeast Philadelphia station. The architectural features will be treated in a different style.

Boiler Room

The equipment of the boiler rooms is to be of the same general type as described for the other station. Because of the larger total capacity required, there are two rows of boilers in each house, with an overhead coal bin between them. The coal and ash handling equipment is similar to that at the other station.

Pump Rooms.

With the exception of the larger units involved, the description of the motor driven design for the Northeast Station is applicable to this plant. To meet the ultimate demands, this station will require eight 100 million gallons per day pumps; the enormous quantity involved here may be better grasped if one realized that the above total pumping capacity will discharge a stream 60 feet wide, 10 feet deep and moving at the rate of about 120 feet per minute.

LINDEN AVENUE & MILNOR STREETS PUMPING STATION.

At the intersection of the above named streets, it becomes necessary to raise the level of the intercepting sewer coming South on Milnor Street, taking the sewage from Torresdale. It therefore is necessary to provide a pumping station for the elevation of the sewage. The quantity involved is relatively small (1950 minimum storm flow is only 5 cubic feet per second), but absolute reliability must be ensured. It is proposed to install three 1000 gallons per minute vertical shaft centrifugal pumps, driven by alternating current motors drawing on the Torresdale Pumping Station of thewater filtration works for this power. The pumps will be set in a dry well; they will draw from an open suction chamber and discharge the sewage into the higher sewers running West on Linden avenue. The architectural features of the small building may be determined upon at a future date, when its construction may be demanded.

40TH WARD STORM WATER PUMPING STATION.

Incidental to the location of a large sewage pumping station in the 40th ward, but not properly included, except in a descriptive sense, in the comprehensive plan, is the establishment of a storm water pumping station contiguous to the other.

There are approximately 4000 acres of low lands in this part of the City dependent for drainage entirely upon the ditches, which discharge through sluices, supplemented at present by the old Mingo creek pumping station.

The ground is nearly all below high tide, and as there have been constructed within this territory hundreds of houses, it is most probable that the permanent grade will remain as at present.

The continued building up of the territory and the improvement of the streets, will eventually cause interference with the ditches, and then ultimate abandonment. The growth of impermeable pavements will increase the volume and velocity with which storm water will reach the lower ground, so that to prevent flooding and protect the properties, the establishment of a pumping station to raise this storm water over the banks into the Schuylkill river is essential.

The details of the requisite sewer and storm water collecting system, together with the necessary reservoirs and the full pumping station equipment and operating details have been worked out, but as the development of the station is independent of the sewage disposal question and estimate, except as to the quantity of sewage to be taken care of, and may be properly classed under annual extensions, the detailed description is omitted.

APPENDIX C.

ALTERATIONS

and

ACCESSORIES.

ALTERATIONS AND ACCESSORIES.

Repairs.

The plan described in a preceding appendix does not include essential alterations and extensions of the existing sewer system. This part of the work must be undertaken from year to year so that when the whole system is completed they will form a part of the comprehensive plan. In the study of the requirements in this respect, a corps of men was organized for the purpose of examining the condition of many of the larger sewers which by reason of failures after heavy storms require repairs. There were examined no less than twenty main sewers of an aggregate length of 45 miles, for each of which a detailed plan and report were filed showing the present condition of every part of their lengths. Careful estimate was made of the cost of placing these sewers in proper repair, the aggregate of which will be found under estimates.

Extensions.

There are certain extensions in the project of the intercepting system, covering among others, the continuation of the intercepting sewer along the line of Cobbs creek as far North as the County Line, portions of which have been under construction for some years past, the construction of intercepting sewers along each side of the Mill Creek main sewer, the building of intercepting sewers as occasions demand along the line of Pennypack creek, Frankford creek and along various other of the larger streams within the City.

These extensions may be built from year to year and charged to annual appropriations for extensions of the existing system, but in conformity with the comprehensive plan. These constructions are readily adaptable to the plan as a whole and in fact the comprehensive plan is predicated upon their being carried out. Where new sewer systems are being carried out

being laid out, the plans contemplate the introduction of the separate system of collection.

Pennypack Creek Sewage Disposal Works.

As a part of the main plan, in which a beginning has already been made by authority of Councils, may be mentioned the Pennypack Creek disposal works, which may be described briefly as follows:

The City having acquired considerable ground on both sides of Pennypack creek for Park purposes and having contiguous to the outlet of the creek various penal and public institutions together with the Torresdale water purification works, it was desirable to collect the drainage from these institutions and from the adjacent settlement of Holmesburg so as to restore the water of Pennypack creek to an unpolluted condition and by treatment of the intercepted sewage protect the intake to the filtration plant. The plant consists of a pumping station located upon park property, and upon other city property, disposal works comprising sedimentation tanks of the Imhoff type used in the Emscher district of Germany, percolating filters, final sedimentation basin and disinfection, all of which were required by the State Board of Health at this point.

A permit for the operation of this plant was granted until such time as the sewage can be treated at a point more remote from the intake of the Torresdale Filtration works.

Alterations.

As part of the alteration required under the plan advocated, it may be mentioned that upon every main sewer outfall at the river banks, as it exists at the present day, there must be constructed outfall chambers with tide gates to prevent the inflow of water into the intercepting system as the tide rises, but to permit the free outflow of storm water to the rivers. The cost of this work is necessarily included in the estimate of the comprehensive plan.

Another alteration to the existing system will be the construction of automatic float control apparatus for intercepting the dry weather flow and a percentage of storm flow from main sewer tributaries to the intercepting sewers or collectors, wherever these main interceptors pass under the main combined sewers of the present system. The cost of this is also pproperly included in the estimate of the comprehensive plan.

Reconstruction.

It has been found also that some of the old sewers have been constructed at such low elevations near their outfalls as to increase the cost of constructing the main collectors. In some cases, it is practicable and advisable to reconstruct portions of these old sewers at their outlets, the cost of which is also properly chargeable to the item for alterations and extensions, which should come from annual appropriations for this purpose.

There will be found below, a list of the sewers which have been examined and those which require repairs together with the estimated cost of making these repairs and the other extensions that are enumerated above.

EXAMINATIONS OF OLD SEWERS, 1910.

SEWERS REQUIRING RECONSTRUCTION.

*

Name of Sewer.	Miles Examined	Location of Recommended Reconstruction	Estimated Cost
Cohocksink System.	1.08	In Thompson St. from Randolph St. to 15th St.	150,000
Christian St. System	1.61	Delaware River to 13th St, and in 13th St. Christian St. to South St.	250,000
Passyunk Ave.	0.29	Christian St. to Ellsworth St.	20.000
Aramingo System.	0.88	In Huntington, Sergeant, Amber, and Coral Streets.	70,000
York St.	0.63	Emerald St. to American St.	81,000
Cohocksink	0.60	Allen St. to Van Horn St.	30,000
Cohocksink System.	0.53	In Mascher, Oxford, and Howard Sts.	28,000
" "	1.08	In Hancock, Laurel, Bodine & Culvert St.	65,000
" "	0.53	Randolph St, Oxford St. to Montgomery Ave.	70,000
" "	0.70	In 18th St. and in Berks St. from 18th to 21st Sts.	22,000
" "	0.16	In Wildey St. and 2nd St.	25,000
Mill Creek System.	5.11	In 43rd St, from Woodland Ave. to Spruce St.	50,000
" "	0.72	In 46th St, Sansom St. to Pine St.	10.000
Larchwood Ave.	0.91	Schuylkill River to 31st St.	65.000
13th St.	1.34	Lombard St. to Pine St.	9,500
Dock St.	0.35	Delaware River to 3rd St.	20,000
19th St.	0.38	Federal St. to Catharine St.	20,000
Fairmount Ave.	1.72	Delaware River to 5th St.	105,000
Ellsworth St. System.	1.13	In 25th St, Federal to Ellsworth St.	22,000
Mantua Creek System.	1.16	In Zoological Garden & Fairmount Park.	90,000
" "	0.28	In 38th St, Brown St. to Wallace St.	34,000
			1,236,500
For alterations to present sewer outlets in conformity to the proposed plan.			263,500
			1,500,000

Note: The above does not include the reconstruction and repair to the Cohocksink System required by examinations made prior to 1910.

-APPENDIX D

ESTIMATES OF THE COST OF THE

COMPREHENSIVE PLAN

81-001

NORTHEAST SEWAGE DISPOSAL WORKS.

SECTION A.

	Cost of Construction	Annual Charges Operation	Depreciation	Interest
Land required for complete plant	625,000			25,000
Intercepting sewers with tide gates and interceptors	550,000	1,500	483	22,000
Grit Chamber, screens and submerged outfall	206,000		2,400	8,240
Pumping station with accessories as of 1910	1,000,000	118,880	42,100	40,000
Grading of streets, and lot about pumping station	75,000			3,000
	2,456,000	120,380	44,983	98,240
Engineering&Contingencies 15%	368,400			14,736
Technical Force		3,000		
	2,824,400	123,380	44,983	112,976

NORTHEAST SEWAGE DISPOSAL WORKS.

SECTION B11

	Cost of Construction	Annual Charges Operation	Depreciation	Interest
Carried forward Section A	2,456,000	120,380	44,983	98,240
Conduits to and from Sedimentation tanks	176,000		500	7,040
Sedimentation tanks and appurtenant work	335,000	3,500	1,050	13,400
Sludge drying beds and appurtenent work	57,000	6,255	1,710	2,280
Submerged outfall	142,000			5,680
Grading Streets	49,000			1,960
	3,215,000	130,135	48,243	128,600
Engineering & Contingencies 15%	482,250			19,290
Technical Force		11,000		
	3,697,250	141,135	48,243	147,890

NORTHEAST SEWAGE DISPOSAL WORKS

SECTION C_{11}

B_{11}

	Cost of Construction	Annual Charges Operation	Depreciation	Interest
Carried forward Section B_{11}	3,215,000	130,135	48,243	128,600
Pumping Station at Milnor St.	17,000	6,120	517	680
Intercepting sewer with tide gates and interceptors	700,000	1,500	945	28,000
Sedimentation tanks and appurtenant work	173,000	2,250	525	6,920
Conduits to and from sedimentation tanks	22,000		500	880
Sludge drying beds	31,000	4,380	855	1,240
Grading	3,000			120
	4,161,000	144,385	51,585	166,440
Engineering&Contingencies 15%	624,150			24,966
Technical Force		11,000		
	4,785,150	155,385	51,585	191,406

NORTHEAST SEWAGE DISPOSAL WORKS.

SECTION D_1

	Cost of	Annual Charges		
	Construction	Operation	Depreciation	Interest
Carried forward Section C_{11}	4,161,000	144,385	51,585	166,440
Intercepting sewers with tide gates and interceptors	440,000	1,500	405	17,600
Conduits to and from sedimentation tanks	150,000		500	6,000
Sedimentation tanks and a appurtenant work	340,000	3,500	1,050	13,600
Sludge drying bed	56,000	6,255	1,710	2,240
Grading	31,000			1,240
	5,178,000	155,640	55,250	207,120
Engineering&Contingencies 15%	776,700			31,068
Technical Force		14,800		
	5,954,700	170,440	55,250	238,188

Erase

NORTHEAST SEWAGE DISPOSAL WORKS.

SECTION E_1

	Cost of	Annual Charges		
	Construction	Operation	Depreciation	Interest
Carried forward Section D_1	5,178,000	155,640	55,250	207,120
Grit chamber and screens	45,000		3,150	1,800
Force Main	149,000	9,000	1,000	5,960
Sedimentation tanks ← Sludge drying beds	667,000	7,000	2,100	26,680
Sludge drying beds	135,000	12,510	3,420	5,400
Percolating filters and appurtenant work	3,052,000	55,845	78,760	122,080
Submerged outfall	107,000			4,280
Sludge steamer	200,000	32,500	20,000	8,000
Grading	630,000			25,200
Additional cost operating Pumping Station /	27,000	27,000		
	10,163,000	299,495	163,680	406,520
Engineering&Contingencies 15%	1,524,450			60,978
~~Operating Pumping Station~~		27,000		
General Labor Force		23,450		
Technical Force		41,375		
	11,687,450	364,320	163,680	467,498

NORTHEAST SEWAGE DISPOSAL WORKS.

SECTION F_1

	Cost of Construction	Annual Charges Operation	Depreciation	Interest
Carried forward Section E_1	10,163,000	299,495	163,680	406,520
Pumping machinery	234,000	50,160	11,700	9,360
Force Main	16,000			640
Sedimentation tanks	474,000	4,750	1,575	18,960
Sludge drying beds	136,000	8,130	2,565	5,440
Percolating filters	1,005,000	16,425	26,420	40,200
Settling basins	200,000	11,565	4,000	8,000
	12,228,000	390,525	209,940	489,120
Engineering&Contingencies 15%	1,834,200			73,368
General Labor Force		28,140		
Technical Force	[illegible]	45,775		
	14,062,200	464,440	209,940	562,488

Southwest

SOUTHWEST SEWAGE DISPOSAL WORKS.

SECTION G.

	Cost of Construction	Annual Charges Operation	Depreciation	Interest
Land acquired for Plant	400,000			16,000
Intercepting sewers with tide gates and interceptors (including siphon)	6,411,000	4,500	1,365	256,440
Screens and Grit chamber	200,000		6,725	8,000
Pumping station and machinery as of 1910	1,265,000	168,340	56,630	50,600
Force Main and conduit to Delaware river	476,000			19,040
Submerged outfall	77,000			3,080
	8,829,000	172,840	64,720	353,160
Engineering&Contingencies 15%	1,324,350			52,974
	10,153,350	172,840	64,720	406,134

South West

SOUTHWEST SEWAGE DISPOSAL WORKS.

SECTION H

	Cost of Construction	Annual Charges Operation	Depreciation	Interest
Carried forward Section G	8,829,000	172,840	64,720	353,160
Conduits to and from sedimentation tanks	367,000		2,000	14,680
Sedimentation tanks	1,230,000	12,750	3,675	49,200
Sludge drying beds	183,000	23,145	6,000	7,320
Water system	14,000		70	560
Grading	239,000			9,560
	10,862,000	208,735	76,465	434,480
Engineering & Contingencies 15%	1,629,300 (300)			65,172
Technical Force		14,800		
	12,491,300 (300)	223,535	76,465	499,652

Southwest

SOUTHWEST SEWAGE DISPOSAL WORKS

SECTION I.

	Cost of	Annual Charges		
	Construction	Operation	Depreciation	Interest
Carried forward Section H	10,862,000	208,735	76,465	434,480
Force main and appurtenant work	35,500	9,000	1,000	1,420
Sedimentation tanks	351,000	3,440	1,050	14,040
Percolating filters and appurtenant work	3,278,000	55,845	78,260	131,120
Sludge beds	51,000	6,255	1,710	2,040
Effluent collector to river	86,500			3,460
Water system	28,000		140	1,120
Grading	425,000			17,000
	15,117,000	283,275	158,625	604,680
Engineering&Contingencies 15%	2,267,550 550			90,702
General Labor Force		23,450		
Technical Force		41,375		
	17,384,550	348,100	158,625	695,382

SOUTHWEST SEWAGE DISPOSAL WORKS.

SECTION J.

	Cost of Construction	Annual Charges Operation	Depreciation	Interest
Carried forward Section I	15,117,000	283,275	158,625	604,680
Intercepting sewers with tide gates and interceptors	4,120,000	1,500	1,200	164,800
Grit chambers and screens	160,000		5,400	6,400
Pumping station - Delaware river part as of 1950	837,000	320,240	36,630	33,480
Force main and appurtenant work	1,525,000	9,000	1,000	61,000
Sedimentation tanks	2,546,000	28,375	8,025	101,840
Sludge drying beds	405,000	49,420	15,195	16,200
Percolating filters S	1,862,000	28,470	47,700	74,480
Outfall collector outfall collector	235,000			9,400
Submerged Outfalls S	140,000			5,600
Water system	80,000		400	3,200
Grading	1,135,000			45,400
	28,162,000	720,280	274,175	1,126,480
Engineering&Contingencies 15%	4,224,300			168,972
General Labor Force		32,830		
Technical Force		81,940		
	32,386,300	835,050-	274,175	1,295,452

SOUTHWEST SEWAGE DISPOSAL WORKS.

SECTION K.

	Cost of Construction	Annual Charges Operation	Depreciation	Interest
Carried forward Section J.	28,162,000	720,280	274,175	1,126,480
Force main and appurtenant work	99,000	18,000	2,000	3,960
Sedimentation tanks	1,175,000	12,750	3,680	47,000
Percolating filters	5,909,000	112,785	153,200	236,360
Sludge drying beds	184,000	22,520	6,540	7,360
Settling basins and sludge pumps	1,139,000	29,080	19,832	45,560
Outfall collector	35,000			1,400
Water system	47,000		235	1,880
Sludge steamer	200,000	37,500	20,000	8,000
Grading	552,000			22,080
	37,502,000	952,915	479,662	1,500,080
Engineering&Contingencies 15%	5,625,300			225,012
General Labor Force		64,710		
Technical Force		134,490		
	43,127,300	1,152,115	479,662	1,725,092